THESIS

THERE AND BACK AGAIN IN THE RAWAH WILDERNESS: REOCCUPATION AT HIGH ELEVATIONS IN THE MEDICINE BOW MOUNTAINS, COLORADO

Submitted by

Paul H. Buckner

Department of Anthropology and Geography

In partial fulfillment of the requirements

For the Degree of Master of Arts

Colorado State University

Fort Collins, Colorado

Fall 2020

Master's Committee:

Advisor: Jason M. LaBelle

Mary Van Buren
Leisl Carr Childers

ABSTRACT

THERE AND BACK AGAIN IN THE RAWAH WILDERNESS: REOCCUPATION AT HIGH ELEVATIONS IN THE MEDICINE BOW MOUNTAINS, COLORADO

This thesis considers the role of reoccupation and persistent use of place in broader systems of high elevation landscape use in the Southern Rocky Mountains. With a geographic focus on the Medicine Bow Mountains of northern Colorado, the study identifies substantive patterns in the assemblage composition, landscape distribution, and surface structure of sites exhibiting evidence of high reoccupation intensity. Following a laboratory analysis of 2,372 artifacts from 30 sites, as well as high resolution mapping of surface artifact distributions in the field, the study identifies several trends with significant potential for clarifying understandings of the precontact utilization of these landscapes. First, a substantial range of reoccupation intensity exists in the surface record of the Medicine Bow Mountains. Second, sites with evidence of preferential reoccupation exhibit significant variability in their assemblage composition, likely reflecting the diverse range of functional activities and transhumance systems associated with their use through time. Third, spatioenvironmental modeling of reoccupation at the landscape scale suggests high elevation contexts, particularly the timberline ecotone, were a focal point of persistent reuse in the study area. Fourth, the surface record of persistently reused places constitutes a palimpsest of time-averaged deposits from many discrete occupations. Analysis of the spatial character and composition of these deposits informs broader understandings of the structure of these sites and the reconstruction of their long-term use through time. These results reinforce the archaeological significance of the Medicine Bow Mountains for clarifying larger patterns in the indigenous use of high elevations in Colorado.

ACKNOWLEDGMENTS

This project was a true collaborative effort, and one which would not have been possible without the support of dozens of individuals and organizations. Countless mentors, colleagues, and friends have supported me throughout my time in graduate school and I would like to sincerely thank each and every one of them for their advice and encouragement. I am truly thankful for all who contributed to make my time in Fort Collins a success.

Jason LaBelle, my graduate advisor, was a consistent beacon of support and inspiration throughout this project. Ever since Jason first brought the Rawah collections to my attention, I have been sincerely thankful for the wonderful opportunity he provided me to work with such amazing archaeology. Jason's mentorship has been crucial in pursuing my academic and professional goals, and I owe much of my success to his tireless efforts on my behalf. From Lake Theo to Nine Mile Canyon, it has been such a privilege to study with Jason. My thesis committee members, Mary Van Buren and Leisl Carr Childers, were likewise a source of much encouragement and many useful conversations. I would also like to recognize Elizabeth Morris, Michael Metcalf, and their student crews for laying the foundation for this study. Susan Struthers and members of the Roosevelt National Forest Heritage Program were likewise enthusiastic supporters of this project and made our 2019 fieldwork possible.

A small number of friends and colleagues were especially critical to my success in completing this thesis. First, I would like to thank my friend and office mate, Marie Matsuda, for all she has done to help me navigate the trials and challenges of graduate school. Over many americanos, Marie was always willing to offer sound advice and a sympathetic ear. Kelton Meyer, Ray Sumner, and Michelle Dinkel were true archaeological role models who shaped my experience at CSU and will continue to influence me through my career. Amber Czubernat made

critical contributions to this project, and her assistance analyzing over 2,000 artifacts made her an indisputable lifesaver. I would also like to recognize the volunteers who participated in fieldwork for this project, Kelton Meyer, Marie Matsuda, Matt Ballance, Carly DeSanto, Tyson Arnold, Will Kane, Colt Johnson, Leslie Moore, Madde Kunkel, Amber Czubernat, and Devan Green. These volunteers contributed 370 working hours and backpacked over 235 cumulative miles in support of this research. Despite the regular freezing thunderstorm, their spirits were always high. I am looking forward to working with all of you again sometime soon!

In addition to these colleagues, I have been fortunate to have had the support of a number of organizations. The James and Audrey Benedict Fund for Mountain Archaeology and the Center for Mountain and Plains Archaeology supported this project and provided me with innumerable opportunities for my professional development as an archaeologist. The Karen S. Greiner Endowment for the Preservation of Colorado Archaeology and the Colorado Mountain Club Foundation were instrumental in acquiring necessary supplies and materials to support my analysis. Additional support for my project was contributed by the Rocky Mountain Urban and Regional Information Systems Association, the Northern Colorado Chapter of the Colorado Archaeological Society, and the Loveland Archaeological Society. The generosity and community offered by these organizations was a true highlight of my time at CSU.

Finally, I would like to thank my parents, Lee Ann and Michael, and brother, Mark, for decades of support on my path to becoming an archaeologist. Contrary to my expectations, my parents were unfazed when I announced I had decided to major in anthropology. Mark has likewise been a lasting source of ($6) support which I am truly thankful for. I would also like to thank Leslie Moore for her companionship and encouragement, and for always being willing to explore around the next bend in the trail.

DEDICATION

Dedicated to my grandfather, Wade William “Poppy” Smith (1937 - 2020).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 – INTRODUCTION

Ancient Native Americans lived in and used the Southern Rocky Mountains of northern Colorado for at least 10,000 years (Brunswig and Pitblado 2007; LaBelle 2012; Morris 2010). Since the beginning of the Early Holocene, when these indigenous peoples are first believed to have traveled through the high mountain passes of the Rocky Mountains in the wake of receding glaciers, humans have made extensive use of the Colorado high country. These first mountaineers were not just visitors to these rugged and unpredictable environments, but active participants who quarried raw materials for stone tools, constructed sophisticated game drive systems, and established places of reverence and religious reflection (Bamforth 2006; Benedict 1992; LaBelle and Pelton 2013). While we know the Arapaho, Cheyenne, and Ute peoples inhabited northern Colorado at the time of contact, and continue to maintain deep cultural and ancestral ties to these landscapes, there remains thousands of years of rich indigenous history in this region about which we know comparatively little. In recognition of these deep human ties to the mountains, we must approach the archaeological record of the Southern Rocky Mountains as an inherently cultural landscape with significant meaning to ancestral peoples and descendent populations. Exploring the ways in which these peoples perceived and used these mountain environments is necessary for generating a richer and more complete record of the human past in the northern Colorado region.

Study of the persistent reuse of place in forager systems is a critical consideration for archaeologists who seek to reconstruct larger patterns in hunter-gatherer lifeways. Persistent places, distinctive locales on the landscape which have been consistently reoccupied over long periods, can provide insight into the dynamic processes behind site selection and landscape use which influenced patterns of hunter-gatherer mobility and settlement through time (Bender 2015;

Dooley 2004, 2008; Schlanger 1992; Shiner 2009). In alpine and subalpine contexts, where year-round human occupation was impeded by harsh winter conditions, recognition of the preferential reuse and persistent reoccupation of place is necessary for making broader insights into high elevation landscape use. Mountain archaeology is associated with many research challenges, and the ephemerality of most high elevation occupation events can pose significant challenges to investigation. To resolve these uncertainties, archaeologists must employ a holistic landscape approach to consider the interconnected nature of mountain settlement systems and the accumulated use of a place through time. In the course of these investigations, analysis of the "organizational relationships" between place and landscape become a necessary consideration (Binford 1982:5). Particularly in mountain contexts, where Bender (2015:300) recognized that "variation in local environmental conditions will create variability across settlement systems", there is a heightened need to consider the reciprocal roles of landscape and human agency in the use of those environments (Rademaker and Moore 2019). Though rugged terrain and adverse conditions imposed substantial constraints on human occupation of high elevation environments, a high degree of variability existed in hunter-gatherers' use of these landscapes, and analysis of the persistent reuse of place is imperative for interpreting these patterns.

The study of persistent land use and reoccupation are both rooted within the broader themes of place, space, and mobility in forager systems. The ancient hunter-gatherers who occupied the Southern Rocky Mountains practiced a mode of subsistence which was inherently mobile and structured around seasonal access to resources (Benedict 1992). These relationships between place and mobility were closely aligned, and consideration of their complimentary roles is necessary for understanding larger trends in the use of mountain landscapes. While there can be substantial variability in the mobility systems practiced by hunter-gatherer groups across the forager-collector continuum, the patterns of persistent land use revealed by these seasonal movements are critical for interpretation of reoccupation in hunter-gatherer lifeways (Binford 1980; Kelly 2013; Smith and McNees 2011). Similarly, these ancient peoples covered considerable distances as part of their seasonal mobility systems and these movements were organized around places on the landscape where people carried out a diverse range of activities ranging from toolstone quarrying to communal hunting (Bamforth 2006; Benedict 1992; Binford 1982). Recognition of persistent reuse of place in these systems can then yield valuable insights into the ways in which hunter-gatherers organized their movements over the landscape and prioritized different aspects of these seasonal rounds.

To address these considerations, this thesis applies a multiscalar approach which examines overarching patterns surrounding reoccupation and persistent place formation in the archaeological record of the Medicine Bow Mountains. By employing conceptual themes from persistent place theory, and methodological considerations from landscape and surface archaeologies and the analysis of time-averaged deposits, this study aims to synthesize these data into a cohesive profile for the persistent reuse of place at high elevations in the Rawah Wilderness. To achieve this goal, I apply a mixed methodological approach. First, extant collections from the study area are analyzed to identify a baseline range of reoccupation intensity for the Medicine Bow Mountains. Second, the spatial distribution of reoccupied sites is considered to investigate if significant contrasts are detectable in the relationship between certain landscape characteristics and preferential reoccupation. Third, I investigate the surface distribution of artifacts at persistently reused sites and evaluate the site structure of reoccupation in relation to landscape features and previous occupations. Based on these theoretical and methodological approaches, the overarching objective of this study is to clarify understandings of landscape use, settlement, and persistent place formation in the Medicine Bow Mountains.

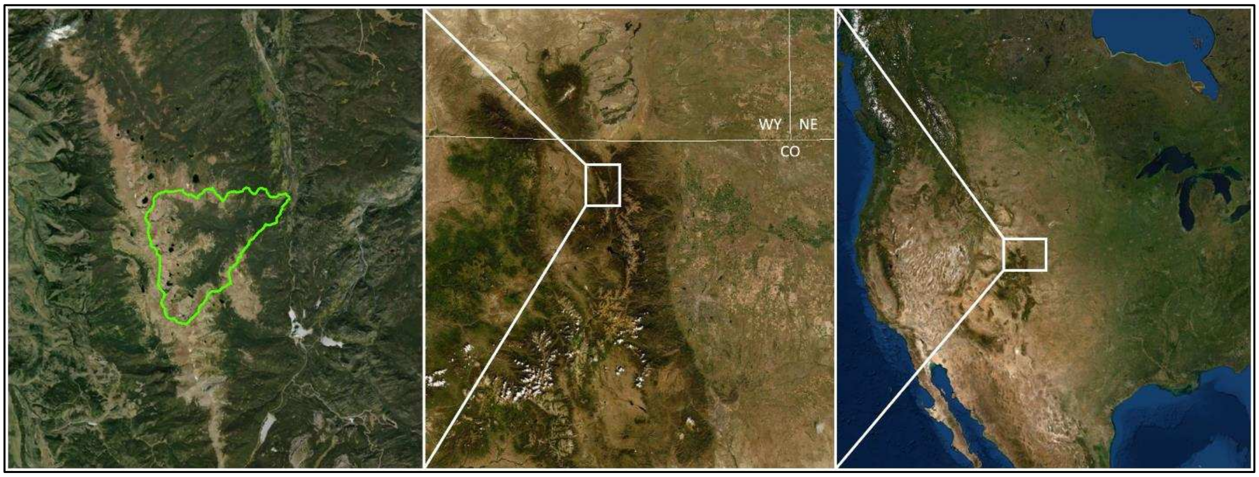


Figure 1. Location of the study area (shown in green, at left) within western North America and northern Colorado. The study area, the naturally delineated West Branch of the Laramie River (WBLR) watershed, encompasses 36.9 square kilometers of mountainous terrain.

The West Branch of the Laramie River (WBLR) Watershed

The West Branch of the Laramie River (WBLR) watershed, located in the Medicine Bow Mountains of northern Colorado, was selected as the study area for this analysis. The WBLR watershed encompasses a diverse range of high elevation ecosystems and mountain settings in a 36.9 square kilometer area, which create a valuable microcosm for analysis of the dynamic nature of indigenous landscape use in high elevation contexts. Similarly, as a naturally delineated boundary, the WBLR watershed is less susceptible to the problematic sampling issues of artificial political boundaries. The watershed is located in western Larimer County, some 67 kilometers (42 miles) west of the city of Fort Collins (Figure 1). The Medicine Bow Mountains are a constituent range of the Southern Rocky Mountains and border the Colorado Front Range to the south. Rocky Mountain National Park is located just 15 kilometers (9 miles) south of the study area and North Park is immediately adjacent to the west. To the north of the WBLR watershed, the continuation of the Medicine Bow Range extends into Wyoming and the Laramie

Basin. The Laramie River Valley is located adjacent to the east of the study boundary, and the Laramie River itself runs north before trending east and ultimately joining the North Platte River.

The geomorphology of the study area is largely glacial in nature, and the upper elevations of the WBLR watershed are characterized by well-defined cirque basins associated with alpine lakes and tarns (Morris et al. 1994; Workman et al. 2018a, 2018b). The WBLR and the North Fork of the WBLR confluence within the watershed, forming a distinctive sideways ‘V’ which is clearly visible in satellite imagery (Figure 1). Elevation ranges substantially in the study area, from 2,620 meters (8,595 feet) at the mouth of WBLR to 3,948 meters (12,953 feet) at the summit of Clark Peak, the highest point in the Medicine Bow Range. Rawah batholith formations comprise the dramatic granitic uplifts of the Rawah Peaks and surrounding summits, while Pinedale-aged glacial till and recent Holocene alluvium fill the lower WBLR valley (Workman et al. 2018a, 2018b). Ancient glacial caps, which extended over the Southern Rocky Mountains in the geologic past, heavily shaped the geology of the study area through divergent periods of glaciation and deglaciation through the terminal Pleistocene (Workman et al. 2018a, 2018b). While most of these geomorphic processes pre-date human occupation of the area, the Pinedale Glaciation is known to have overlapped with the earliest human colonization of the northern Colorado region (Brunswig and Pitblado 2007; LaBelle 2012; Workman et al. 2018b).

In addition to the variable terrain and geology associated with the study area, a diverse range of mountain ecologies are also present (Veblen and Donnegan 2005). The montane, subalpine, and alpine ecozones, as well as their interceding ecotones, are all represented in the ecology of the watershed (Figure 2, Figure 3). Culturally significant floral and faunal species are likewise found throughout the study area. Bison (*Bison* bison), bighorn sheep (*Ovis canadensis*), elk (*Cervus elaphus*), and mule deer (*Odocoileus hemionus*) were known to have historically occupied the high elevations of the Rawah Wilderness and were likely prey for the ancient hunters who occupied the watershed (Meaney and Vuren 1993:5). Edible plant species were likewise abundant within the study area and included dandelion (*Taraxcum sp.*), wild strawberries (*Fragaria sp.*), and sorrels (*Oxyria* and *Rumax sp.*) (Benedict 2007; Morris et al. 1994:67). No known sources of toolstone exist within the watershed and its immediate surroundings, however small pockets of limestone and volcanic deposits in geologic faults abutting North Park may have yielded isolated deposits of suitable lithic materials (Black 2000; Morris et al. 1994:74; Morris and Marcotte 1976:25; Workman et al. 2018).

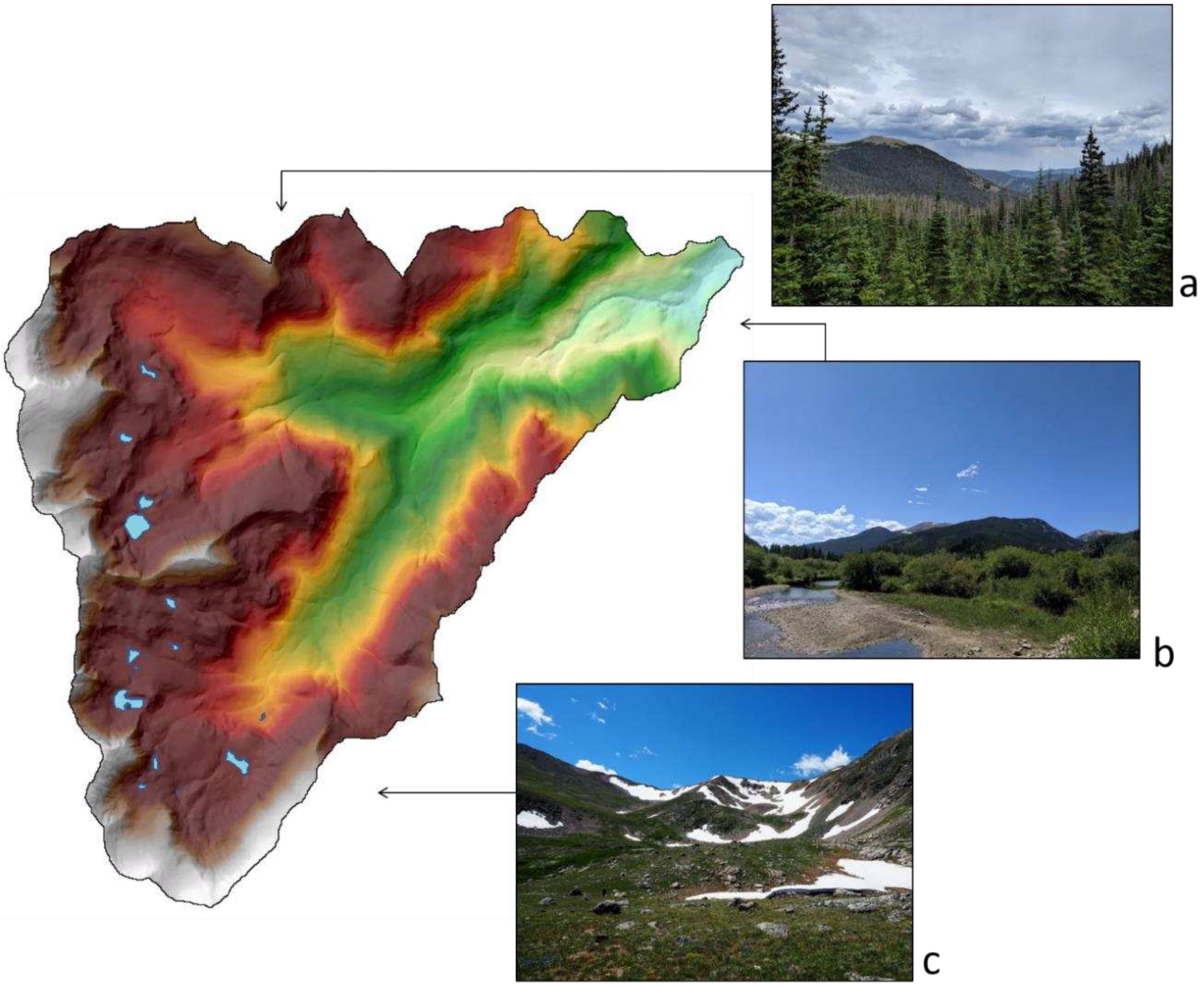


Figure 2. Variability in elevation and terrain within the study area. A diverse range of mountain environments exist in the watershed, including (**a**) incised glacial valleys and subalpine forests, (**b**) dense riparian vegetation at river confluences, and (**c**) alpine tundra and cirque basins.

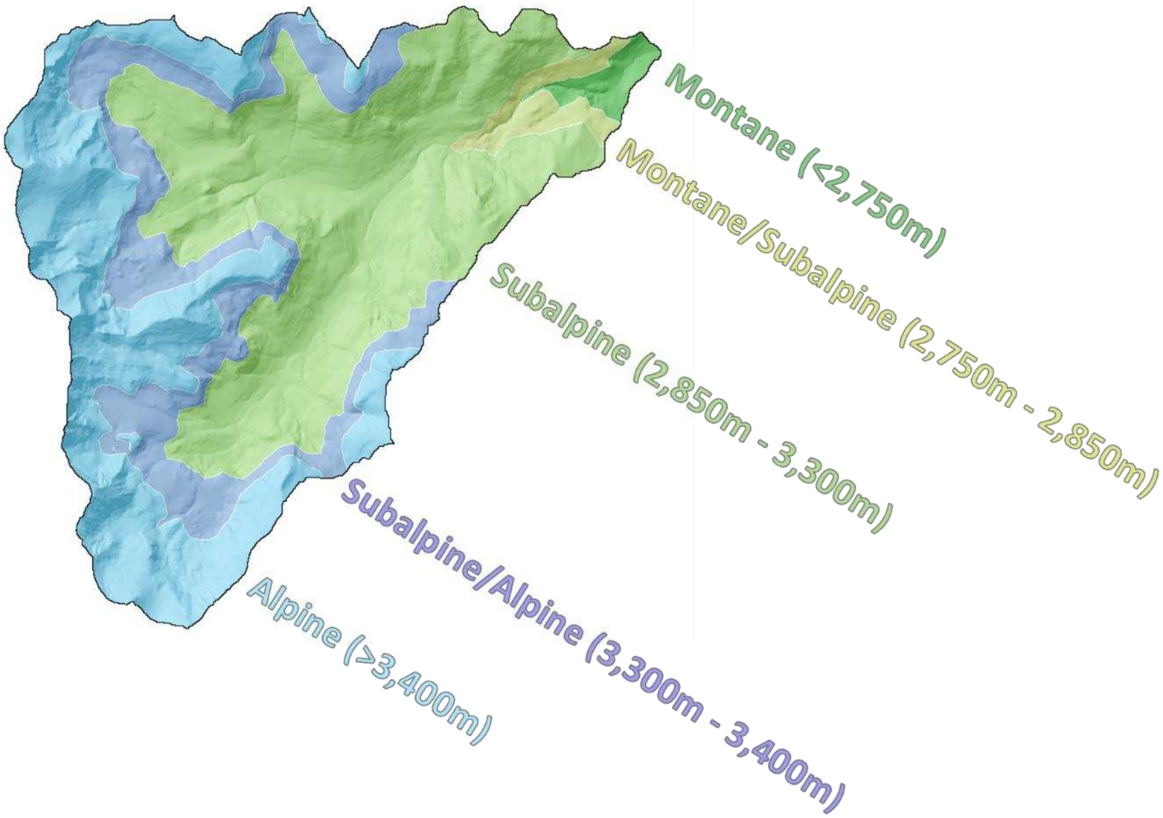


Figure 3. Ecozones and transitional ecotones of the West Branch of the Laramie River (WBLR) watershed. The watershed encompasses a diverse high elevation landscape, with a wide variety of ecological settings represented.

Collectively, the diverse ecological and geomorphologic settings found in the WBLR watershed form an optimal laboratory for analysis of hunter-gatherer landscape use at high elevations. Access to the watershed was limited by a small number of traversable passes and drainages, neatly delineating the physical extent of the study area on the landscape. Ancient peoples, and modern recreationalists today, entered the watershed by crossing Grassy Pass in the north, Blue Lake Pass in the south, or by traveling up the WBLR valley from the river's confluence with the greater Laramie River. The limited accessibility of the watershed creates a neatly encapsulated high elevation microcosm, where hunter-gatherer movements and settlement within that closed system can be closely investigated. Alongside a large quantity of known sites within the study area, discussed in-depth in the succeeding chapter, these environmental characteristics demonstrate the high analytical value of the WBLR watershed (Figure 4).

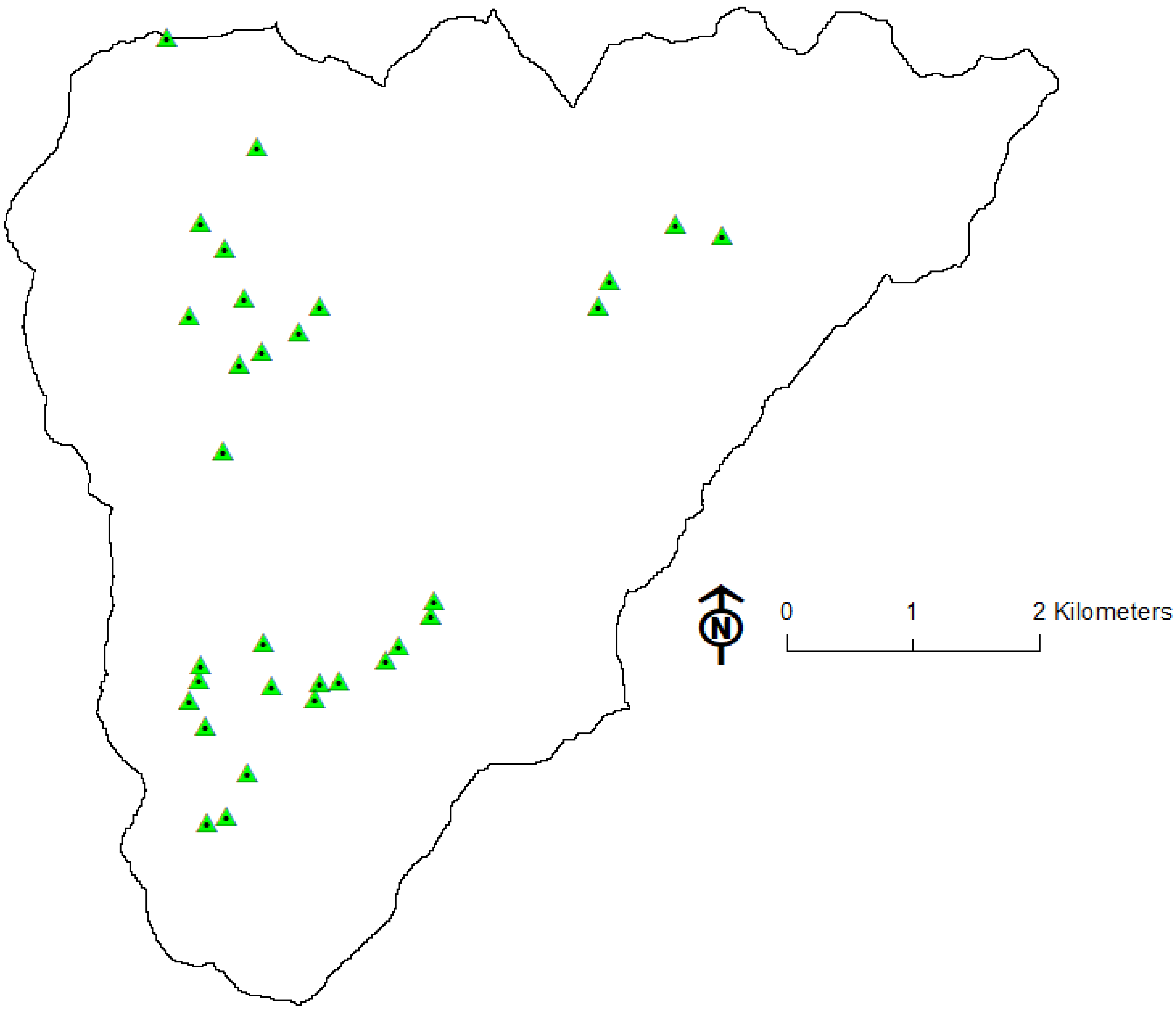


Figure 4. Locations of sites (n = 31) described in this study. 5LR17 is discussed in Chapter 2 but otherwise omitted from the analysis due to the incompleteness of the available sample. Not shown is the Carey Lake site (5LR230), which was not considered in the study due to its inclusion in an ongoing research program (Meyer 2019b). Contextual geographic information is not shown to protect resource locations.

Primary Research Questions and Organization

With the objective of isolating the dynamic processes behind preferential reoccupation in high elevation environments, this study is organized around three scales of inquiry which address the assemblage-level, landscape-level, and site-level manifestation of landscape persistence. To support this analysis, Chapters 2 and 3 define the contextual and theoretical foundations of the study. Chapter 2 discusses the known archaeological record of the Medicine Bow Mountains, alongside a description analysis of existing collections from Metcalf (1971a), Morris et al. (1994), and Wheat (1947). This chapter outlines the known chronology of the study area, summarizes the history of previous archaeological investigations in the WBLR, and discusses the range of variability in the material record of the WBLR watershed. Chapter 3 opens with a brief exploration of the high elevation archaeological record of northern Colorado, which is evaluated for the purpose of developing expectations for reoccupation and persistent reuse in the Medicine Bow Mountains. Following this, the chapter explores the persistent place and palimpsest concepts, alongside method and theory in the study of reoccupation, to define a priori expectations for reuse and reoccupation of sites in the Medicine Bow Mountains.

With these contextual and theoretical frameworks established, the thesis addresses the study's principle research questions in three analytical chapters. Chapter 4, which represents the first scale of analysis, considers the assemblage composition of sites from existing collections to identify a range of reoccupation in the study area. Through a laboratory study of artifacts collected by Metcalf (1971a) and Morris et al. (1994), this chapter contextualizes the analysis of these extant surface assemblages with the expectations outlined in Chapter 3. The objective of the chapter is to provide an analytical baseline for preferential reoccupation in the Rawah Wilderness, which addresses two principle questions. First, what is the range of reoccupation intensity in the study area? And second, can reoccupation be recognized from analysis of mixed surface collections?

With a defined range of reoccupation intensity for the study area, and ordinal classification of sites by reoccupation intensity, into high reuse, moderate reuse, or low reuse classes, Chapter 5 employs a distributional approach to evaluate the implications of landscape settlement for preferential reoccupation. Through advanced spatiotemporal modeling, using a maximum entropy (Maxent) methodology, this chapter compares spatial models for the landscape suitability of high, moderate, or low reuse sites. The results of the modeling, derived from analysis of environmental variables and best available archaeological data, identify divergent patterns in the distribution of reoccupied sites across the larger watershed. Using these methods, the objective of the chapter is to better understand the role of high elevation landscapes in encouraging or discouraging reuse of place. The chapter asks, is there an identifiable landscape or ecological signature for persistent reoccupation? To what degree do environmental conditions contribute to high degrees of reuse? Are there substantive differences between environmental conditions associated with high, moderate, or low evidence of reoccupation? And, how does reoccupation intensity vary across diverse ecological and environmental conditions?

With this improved understanding of assemblage composition and the landscape distribution of reoccupied sites, and their implications for persistent use of place, the final analytical chapter considers the spatial structure of preferentially reused sites. While the previous chapters rely on existing data, Chapter 6 applies spatial analyses to a newly collected field dataset from 2019 (Buckner 2019). Through analysis of surface artifact distributions, this chapter explores the dynamics of site structure through time, the formation and character of associated palimpsest deposits, and analysis of time-averaged surface contexts. In meeting these objectives, the chapter asks, to what degree is reoccupation recognizable from surface contexts? How is reoccupation reflected spatially in the distribution of artifacts at sites? And how does variation in artifact distributions inform analysis of reoccupation?

The final chapter, Chapter 7, synthesizes these results to identify overarching patterns associated with persistent reoccupation of high elevations in the Medicine Bow Mountains. Alongside a discussion of how these results could inform broader understandings of high elevation archaeology in the greater Southern Rocky Mountains, this final chapter outlines the larger implications of the study to academia and cultural resource management by discussing their relevance to current discourses in the study of hunter-gatherer landscape use and the archaeology of high elevation environments in northern Colorado. The final pages of the thesis, alongside a discussion of the study's limitations and suggestions for their possible future resolution, discuss future directions for continued research. Collectively, the objective of this final chapter is to define the study's contributions to existing bodies of literature and outline its role in guiding future research in these areas.

CHAPTER 2 – ARCHAEOLOGY OF THE WEST BRANCH OF THE LARAMIE RIVER

The current study is established upon an existing body of research on the archaeology of the Rawah Wilderness. These previous investigations generated a foundation for the high elevation archaeology of the Medicine Bow Mountains, and their findings form a critical component of this analysis. The objective of this chapter, then, is to evaluate these existing data to create a baseline dataset for continued analysis. This is accomplished through discussion of the existing bodies of knowledge for the study area and descriptive analysis of extant collections acquired by Wheat (1947), Metcalf (1971a), and Morris et al. (1994). Analysis of these collections can yield a better understanding of the chronology of foragers' use of the study area, and will consider the variation in material culture commonly associated with sites in the Medicine Bow Mountains. Especially as time forms a critical aspect of this study, this chapter's discussion of projectile point typologies and associated relative chronologies forms an integral component of the analyses presented later in the thesis. With its synthesis of the material culture of the Rawah Wilderness, this chapter acts as a foundation for the theoretical and analytical approaches employed in the later analysis.

The archaeological record of the Rawah Wilderness has been a subject of analysis since at least the mid-20th century (Table 1). In the historic recreational use of the watershed, anglers were reported to have brought "six inch Yumas [lanceolate projectile points] from the high lakes" which dot the cirque basins of the Medicine Bow Mountains (Gary Weinmeister to Jason LaBelle, personal communication 2018). The first documented site in the study area, and just the 17th recorded site in Larimer County, was 5LR17. A Folsom point and Late Prehistoric diagnostics were reported at the site, which was discovered by avocational archaeologist Ralph

Culver and recorded “from data” by Wheat (1947). The presence of a reported Folsom point at 5LR17 has led to its recognition as a rare example of a potential high elevation Folsom site, though the point is not available for study among the known collections from 5LR17 and may remain in the possession of the Culver family (Brunswig 2007:275; Jason LaBelle, personal communication 2018).

Following Culver and Wheat’s (1947) recordation of 5LR17, there is no record of formal archaeological investigation in the Rawah Wilderness until 1971. At this time, Michael Metcalf (1971a) undertook an extensive solo survey of the high elevations of the WBLR watershed as part of his undergraduate research at Colorado State University. Metcalf’s (1971a) intuitive surveys, though aimed at identifying game drives similar to those in the Colorado Front Range, were successful in identifying a large number of sites with high data potential. These discoveries instigated a 25-year longitudinal study of the Rawah Wilderness led by Elizabeth Morris of Colorado State University (Morris and Metcalf 1993; Morris et al. 1994; Morris 2010). Morris and Metcalf’s (1993) work in the Rawah Wilderness aimed to better understand the chronological context and settlement patterns of ancient hunter-gatherers’ in the Medicine Bow Mountains, particularly in relation to the more defined archaeological record of the neighboring Colorado Front Range. In the context of Benedict’s (1985, 1992) work in the Indian Peaks Wilderness, Morris et al. (1994) sought to profile the archaeological record of the Rawah Wilderness and investigate the role of the Medicine Bow Mountains within hunter-gatherers’ lifeways in the larger northern Colorado region. Morris (2010) likewise used these longitudinal approaches to investigate the continued exposure of artifacts on the surface of sites through time. These Colorado State University investigations were successful in contributing an additional 34 sites to the known record of the WBLR watershed and generated large curated collections for analysis. These collections include a small number of obsidian artifacts (n = 5), which were among the materials which LaBelle (2009) considered in his broader sourcing analysis of obsidian artifacts from various sites within the South Platte River Basin. Subsequent studies, following the conclusion of Morris' (2010) work, include limited compliance surveys and an ongoing longitudinal study at the Carey Lake site (5LR230) by the Center for Mountain and Plains Archaeology (Koenig 2018; LaBelle and Meyer 2017; Meyer and LaBelle 2017; Meyer 2018, 2019b, 2019c).

Table 1. History of archaeological investigations preceding the current study. Reproduced with modification from Buckner (2019).

Researcher or Institution	Year(s)	Summary	Citations
J.B. Wheat	1947	Recorded site 5LR17 based on account of Ralph Culver, amateur archaeologist.	Wheat (1947)
M. Metcalf and E.A. Morris (Colorado State University)	1971 – 1996	Surveys, recordation, collection, and analysis of sites in the WBLR and surrounding area; Fieldwork was conducted with support from CSU crews, USDA-FS archaeologist John Slay, and others.	Metcalf (1971a); Morris and Metcalf (1993); Morris et al. (1994); Morris (2010)
USDA - FS	2018	NHPA Section 110 surveys in the lower elevations of the WBLR.	Koenig (2018)
CMPA (Colorado State University)	2009; 2016 - Present	Obsidian analysis (2009); Longitudinal study of the Paleoindian component at the Carey Lake site (5LR230) (2016 – Present)	LaBelle (2009); LaBelle and Meyer (2017); Meyer and LaBelle (2017); Meyer (2018, 2019b, 2019c)

Documented Archaeological Sites and Existing Collections

As of 2020, 37 sites have been formally recorded in the WBLR watershed. This total includes sites documented by Wheat (n = 1), Morris and Metcalf (n =34), and Buckner (n = 2) (Buckner 2019; Morris and Metcalf 1993; Morris et al. 1994; Wheat 1947). For the purposes of this analysis, seven closely situated sites were consolidated into three localities. These localities, 5LR235/5LR273/5LR274, 5LR227/5LR228, and 5LR153/5LR237, were located within 30 meters of the nearest neighboring site(s) and were evaluated as single localities for the analytical portions of this study. The rationale for consolidating these sites was based on the place-oriented approach utilized in this study. With the aim of better understanding ancient hunter-gatherers' use of place, it was critical to eliminate arbitrary delineations in site boundaries which would serve only to break spatially associated assemblages into distinct units and imply non-association (Dunnell 1992). While a true siteless approach was not possible given the nature of the existing datasets, and some reliance on the site concept was therefore necessary, it was important to consider closely spatially associated sites as representative of single places on the landscape. All 27 individual sites, and the three consolidated localities, are associated with existing collections of surface artifacts housed in the Center for Mountain and Plains Archaeology at Colorado State University. During the 25 years of Morris et al.'s (1994) Rawah Wilderness investigations, Morris and Metcalf (1993) employed a strategy which called for surface collection of all tools and debitage during each visit to a site (Morris 2010). Sites were also revisited intermittently during this period, which resulted in extensive surface samples for these sites (Morris and Metcalf 1993; Morris et al. 1994). In contrast to those sites included within Morris and Metcalf's (1993) study, only a partial record exists for the 1st site documented in the study area, 5LR17, as debitage and many reported tools are absent from known collections from the site. The surface sample from the 37th site in the study area, 5LR14336, is likewise partial, as only diagnostics were collected as part of a conventional site recording (Buckner 2019). While these sites are omitted from the analytical portions of this study due to the incompleteness of their surface samples, they are discussed in this chapter and considered in the broader evaluation of the study area's chronology and material culture. One site, the Carey Lake site (5LR230), is not discussed in this chapter or elsewhere in this thesis as it is the subject of an ongoing longitudinal study (Table 1; See Morris et al. [1994] and Morris [2010] for data on collections from the site).

Table 2. Summary table of all known collections from the study area, arranged by individual site number. Collections from 5LR17 are curated at the University of Colorado, while all remaining collections are available from Colorado State University. Counts do not include collections made during 2019 fieldwork (See Buckner 2019).

Site	Assemblage Size (n)	Total Debitage (n)	Total Tools (n)	Projectile Points (n)	Ground Stone (n)	Year Recorded
5LR17	6	0	6	0	1	1947
5LR101	16	11	5	1	0	1974
5LR102	12	9	3	2	1	1974
5LR113	26	23	3	0	0	1974
5LR114	10	10	0	0	0	1974
5LR131	91	86	5	2	0	1971
5LR132	114	111	3	0	0	1971
5LR133	41	35	6	1	2	1971
5LR134	28	23	5	2	0	1971
5LR135	10	8	2	0	0	1971
5LR153	118	115	3	0	0	1971
5LR158	76	73	3	1	0	1971
5LR173	3	3	0	0	0	1979
5LR174	160	147	13	7	0	1979
5LR224	1	0	1	0	0	1972
5LR225	24	21	3	0	0	1971
5LR226	20	18	2	0	0	1971
5LR227	43	38	5	1	0	1971
5LR228	58	50	8	2	0	1971
5LR229	21	13	8	2	0	1971
5LR231	38	34	4	1	0	1971
5LR232	54	50	4	0	0	1971
5LR233	33	25	8	1	1	1971
5LR234	83	79	4	0	0	1971
5LR235	337	331	6	3	1	1972
5LR236	47	44	3	0	0	1971
5LR237	180	162	18	10	0	1971
5LR238	148	142	6	2	0	1971
5LR239	2	0	2	2	0	1972
5LR240	66	53	13	5	1	1972
5LR273	454	434	20	2	0	1972
5LR274	33	29	4	1	0	1972
5LR1733	1	0	1	1	0	1993
5LR1834	23	22	1	0	0	1994
5LR14335	1	0	1	1	0	1994*

* Isolated Paleoindian point collected by Elizabeth Morris circa 1994. OAHP form completed in 2019 (Buckner 2019).

Lithic Raw Materials

Substantial variability exists among lithic raw materials in Rawah Wilderness assemblages, and recognition of this diversity is necessary for reconstruction of hunter-gatherer's use of high elevation environments (Benedict 1992; Reckin and Todd 2020). Previous studies of the Medicine Bow Mountains identified a high degree of heterogeneity in material types and observed that lithic raw materials were imported "a considerable distance" from their sources (Metcalf 1971a; Morris et al. 1994:74; Morris and Marcotte 1976). Geological maps similarly reveal an apparent absence of local lithic raw material sources in the vicinity of the study area (Workman et al. 2018a, 2018b). Similarly, Black's (2000) synthesis of Rocky Mountain lithic raw material sources likewise did not identify any quarriable sources in proximity to the WBLR study area. Continued investigation by Black (2019) and others has recognized the role of small-scale quarries in raw material procurement in the larger North Park region, however there remains no evidence of truly local sources within 20 kilometers of the study area (Binford 1980).

Lithic raw material type was documented for each of the 2,372 artifacts in existing collections from the WBLR, and 265 artifacts mapped in the field, and standardizing classification of lithic raw materials was critical (Buckner 2019). In the early stages of the analysis, Czubernat (2019) investigated variability in lithic raw materials at 5LR174 through a minimum analytical nodule analysis. Following methods in Larson (1994), Czubernat (2019) grouped the 5LR174 assemblage into analytical nodules by evaluating the macroscopic characteristics of each artifact under visible and ultraviolet light. Czubernat's (2019) study identified a surprising range of variability among the material composition of the 5LR174 assemblage, and raw materials initially thought to represent homogenous types were shown to be highly variable (Buckner 2019).

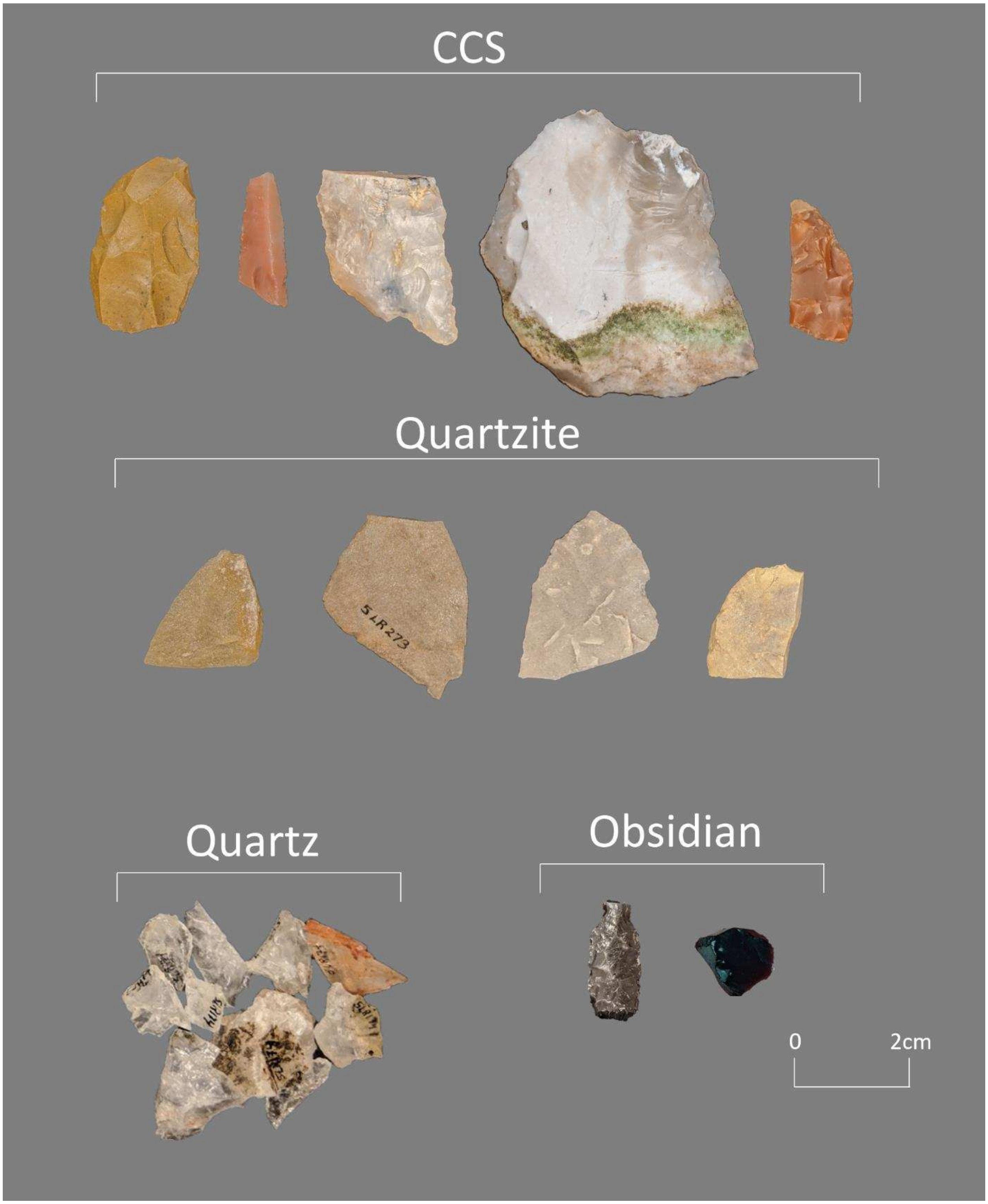


Figure 5. A representative sample of variability among lithic raw materials. Lithic raw materials were categorized into broad classes to minimize subjectivity and ensure the integrity of subsequent analyses. These classes were selected to emphasize qualities which could be objectively identified based on macroscopic characteristics and de-emphasize subjective qualities like coloration, which can vary substantially within a single nodule of raw material.

Table 3. Criteria applied to classify chipped stone raw materials into grouped categories. Materials were classed into CCS, quartzite, quartz, and obsidian categories to minimize subjectivity and error in raw material classification. Table reproduced with modification from Buckner (2019).

Raw Material	Definition	Classification Characteristics
Crypto-crystalline Silicate (CCS)	Lithic materials with fine-grained silicate structures (e.g. chert, jasper, silicified wood, chalcedony).	Fine granular structure, matte or waxy luster, may be opaque or transparent. Diverse colorations. Quartz grains are absent from the matrix.
Quartzite	Silicified quartz-bearing sandstone	Granular structure with visible quartz crystals in silicified sandstone matrix. Diverse colorations. Opaque.
Quartz	Crystalline mineral which occurs in rock veins.	Amorphous granular structure. Typically colorless or white, with possible additional colorations from mineral staining and impurities. Commonly transparent.
Obsidian	'Volcanic glass', formed from rapidly cooled extrusive lava flows.	Glassy appearance. Black or grey coloration with banding possible, may occur in green or maroon varieties. May be opaque or transparent.

Czubernat's (2019) recognition of the high degree of heterogeneity in raw material classes necessitated additional measures to ensure accurate classification of material types for chipped stone artifacts. Particularly as blind studies have suggested that visual identification of raw materials is largely subjective and experience dependent, additional controls were required for field and laboratory classification of material types (Agam and Wilson 2019). To mitigate this issue, and ensure the integrity of raw material classifications, materials were classified into categories with objectively recognizable macroscopic characteristics and a negligible likliehood of misidentification (Figure 5; Table 3). These categories were defined as crypto-crystalline silicate (CCS), quartzite, quartz, and obsidian. CCS encompasses the widest variety of materials, such as cherts, jaspers, and chalcedonies, however this grouping was necessary due to high degrees of overlap between these materials. The "lusterous opaque white chalcedony" described in Morris and Marcotte (1976:21), for example, is identified as “mixed chalcedonic chert” in Buckner (2019:9-10) and a “white to slightly translucent chert” in Meyer (2019c:13). Depending on the portion preserved, two fragments of this common material could be variously identified as either opaque white chert or translucent chalcedony (Buckner 2019). The challenges of classifying this frequently occurring material, alongside similarly subjective materials, underscores the need for controlled standardization of lithic raw material classification.

In contrast to materials classified as CCS, materials grouped into quartzite, quartz, and obsidian categories exhibited little variability. Both quartzite and quartz are readily distinguishable from CCS and obsidian, as well as from each other, and can be consistently identified correctly by crewmembers regardless of experiential level. The quartzite category includes both meta-quartzites and ortho-quartzites, as little functional difference exists between these sub-materials and broader quartzite materials (Black 2000). Among the quartzite assemblage, coloration exhibited the highest variability, as there was limited variation in the granular structure and mineral composition of quartzite artifacts (Figure 5). Similarly, materials designated as quartz were easily distinguishable given their distinctive amorphous granular structure (Driscoll 2011). Obsidian was similarly identifiable with minimal probability of misclassification. Obsidian items considered in the study were limited to opaque black varieties, though a small number of obsidian flakes (n = 4) were not physically inspected by the author due to their temporary withdrawal from the collection for a sourcing analysis (LaBelle 2009; Jason LaBelle, personal communication 2018).

Collectively, though limiting the available resolution, the application of controlled lithic raw material classes was successful in minimizing subjectivity and preserving the integrity of the study’s analysis of raw materials (See discussion in Chapter 4, Chapter 6). In total, of the existing pre-2019 collections of both chipped stone debitage and tools, CCS comprised 78.6% of the assemblages (n = 1,871), quartzite represented 19.7% (n = 469), quartz encompassed 1.2% (n = 28), and obsidian covered 0.21% (n = 5) of the total WBLR assemblage. Lithic materials associated with ground stone technology did not require similar controls given the well-defined macroscopic characteristics of the most common materials, such as sandstone and granite (Pelton 2013; Shropshire 2003).

Tool Typologies and Chronology

This section considers the assemblage of 199 lithics tools from 29 localities in the WBLR watershed. An analysis of tool typologies was undertaken to establish the functional diversity of assemblages in the study area, alongside the contemporaneity or non-contemporaneity of artifacts within those assemblages. Of the tools available for this study, 181 tools were collected during investigations prior to 2019, while an additional 18 tools were collected as part of new fieldwork undertaken for this project (Buckner 2019; See Chapter 6). For each tool, maximum length (mm), maximum width (mm), maximum thickness (mm), and mass (g) metrics were collected alongside presence/absence of heat treatment, lithic material type, and portion. For projectile points, typological classification was recorded alongside additional applicable dimensions such as neck width (mm), base width (mm). Each tool was assigned to 11 pre-defined functional classes, projectile points, bifaces, drills, scrapers, cores, preforms, handstones, netherstones, edge modified flakes, unifaces, and gravers. These classes were defined by their morphological attributes and existing conventions outlined in Andrefsky (1998) and Adams (2002), and were intentionally left as broad categories to minimize misclassification and associated error, better comply with the data needs of the analysis, and to allow for the complete analysis of the total assemblage within the limited time constraints of the study. In total, bifaces (n = 61; 30.7%) comprised the majority of the tool assemblage, followed closely by projectile points (n = 56; 28.1%). Edge modified flakes occurred at the next highest frequency (n = 26; 13.1%), with similar quantities of scrapers (n = 18; 9.1%) and preforms (n = 17; 8.5%). Ground stone was also represented in small quantities, with netherstones (n = 7; 3.5%) and a single handstone (n = 1; 0.5%) collectively representing just 4% of the larger assemblage. The remaining tool classes, which were observed only in small quantities, included cores (n = 4; 2%), drills (n = 3; 1.5%), unifaces (n = 3; 1.5%), and gravers (n = 3; 1.5%). The following sections define and evaluate each tool class in greater detail, alongside representative photographs.

Projectile Points and Temporal Diagnostics

In their analysis of the chronology of the Rawah Wilderness, Morris et al. (1994) described typological evidence for the indigenous occupation of the Medicine Bow Mountains from the Paleoindian period through the Late Prehistoric. Evidence of Protohistoric occupation was absent, however Morris et al.'s (1994) study recognized the long-duration of use and reuse which characterizes the human use of the Medicine Bow Mountains through time. Establishing chronological sequences and applying them to evaluate the long-term patterns of landscape use, in the same way as Morris et al. (1994), is likewise a critical component of this study. In the absence of subsurface investigations and absolute dating, this analysis relies entirely upon established projectile point typologies. In interpreting these typologies, the study applies the regional chronology outlined by Chenault (1999), which identifies three broad periods (Paleoindian, Archaic, and Late Prehistoric), and their associated phases (early, middle, late) (Table 4). Though Morris et al. (1994:70) incorporated other functional tool types behind projectile points into their chronology, such as “beaked end scrapers” and “big knives” as diagnostic markers of the Paleoindian period, this study assigned temporal affiliation based only upon accepted projectile point typologies and preforms with diagnostic characteristics. Only one preform met this criteria, 5LR240-60, and was assigned a temporal affiliation (Figure 6).

Table 4. A regional chronology for northern Colorado, adapted from Chenault (1999) and applied to organize the chronology of the Rawah Wilderness.

Temporal Period	Uncalibrated Date Range (RCYBP)	Representative Projectile Point Typologies
Early Paleoindian Period	12,000 – 11,000	Clovis
Middle Paleoindian Period	11,000 – 10,000	Folsom, Agate Basin, Hell Gap
Late Paleoindian Period	10,000 – 7,500	James Allen, Angostura, Pryor Stemmed, Cody Complex
Early Archaic	7,500 – 5,000	Mount Albion
Middle Archaic	5,000 – 3,000	Duncan-Hanna, McKean Lanceolate, Mallory
Late Archaic	3,000 – 1,800	Yonkee, Pelican Lake
Early Ceramic (Late Prehistoric)	1,800 - 800	Hogback corner-notched
Middle Ceramic (Late Prehistoric)	800 - 410	Plains tri-notch, Plains side-notch
Late Ceramic (Protohistoric)	410 - 90	Metal trade points

Following laboratory analysis of the 56 projectile points present in the WBLR watershed collection, 28 projectile points and one preform were assigned to specific types associated with this regional chronology. An additional 14 points were classed within a broader temporal category but were not assigned to a specific type (e.g. unassigned Archaic). The remaining 14 projectile points, mostly comprised of fragmentary pieces, were classified as unassigned. A conservative methodology was utilized for typological classification of projectile points, and relied upon specimens with complete hafting elements, or defined attributes which strongly aligned with published examples of an accepted type in the archaeological literature.

The results of the projectile point analysis identified seven artifacts associated with the Late Paleoindian period, eleven with the Early Archaic, seven with the Late Archaic, and eight associated with the Late Prehistoric. Projectile point styles predating the Late Paleoindian period were absent, as were examples from the Middle Archaic and Protohistoric. Though Morris et al. (1994) reported the absence of materials associated with the Early and Middle Paleoindian period and Protohistoric period, they did affiliate a number of artifacts with the Middle Archaic. Given the more conservative strategy for typological identification employed here, this study was unable to corroborate Middle Archaic temporal affiliations based upon projectile point fragments without hafting elements.

Artifacts (n = 7) assigned a Late Paleoindian temporal affiliation were comprised of six projectile points and a single preform (Figure 6). 5LR1733-1 is an example of a Late Paleoindian James Allen point (Morris 2010: Figure 1f). James Allen points are dated to approximately 9,350–7,900 RCYBP and are associated with lanceolate forms with parallel to slightly converging bases and a distinctive parallel-oblique flaking pattern (Mulloy 1959; Pitblado 2003, 2007). Notably, these points exhibit a characteristic basal concavity (Pitblado 2003:112). The James Allen type site is located nearby to the study area, in the vicinity of Laramie, Wyoming, and these points are likewise found in similar high elevation contexts and in the foothills of Larimer County (Benedict 1981, 1985; Husted 1965; Pitblado 2000, 2003; Pelton et al. 2016; Morris 2010; Mulloy 1959). 5LR134-26 was also classified as a James Allen projectile point, though with less certainty due to its condition (Figure 6). The artifact appears to represent a basal/lateral fragment of a James Allen point which was reworked at the break along its medial axis. The point does not exhibit a clear parallel-oblique flaking pattern in its current condition, but the absence of this characteristic is explained by significant damage to the point, as reflected by fragmentations spalled from its surface and lateral chipping. 5LR134-26 embodies many aspects of the distinct basal morphology of James Allen points, and its size and characteristics closely align with known examples (cf., Benedict 1981: Figure 67a; Mulloy 1959: Figure 1p).

Figure 6. Projectile points and preform (5LR240-60) diagnostic of the Late Paleoindian period. Top row, from left: A proximal/medial fragment of a James Allen point, a proximal fragment of a probable Scottsbluff point, an unassigned Late Paleoindian projectile point or knife, a possible Foothills-Mountain Complex point. Bottom row, from left: A possible basal fragment of a James Allen point, a proximal/medial fragment of an unassigned Late Paleoindian point, and an unassigned Late Paleoindian preform.

Another point diagnostic of the Late Paleoindian period is 5LR174-150, which is a proximal fragment of a Scottsbluff projectile point. Scottsbluff points are associated with the Cody Complex, and date to approximately 9,400 – 8,300 RCYBP (Pitblado 2003). Scottsbluff forms have likewise been found at high elevations in the Southern Rocky Mountains nearby to the study area, including at Carey Lake (5LR230) and in the Colorado Front Range (Benedict 2000; Brunswig 2007; Ives 1942; Morris 2010). The Horner site is often identified as the type site for the Cody Complex, though Scottsbluff points themselves take their name from the Scottsbluff Bison Quarry (Barbour and Schultz 1932; Frison and Todd 1987; Frison 1991). The points are commonly differentiated into Type I and Type II varieties. Type I points are characterized by transverse flaking, triangular blades, and a stemmed hafting element. Type II forms exhibit similar characteristics, but with wider blades and distinct shoulder definition (Wormington 1957). Due to the fragmentated nature of the specimen, it is not clear whether 5LR174-150 represents a Type I or Type II point. A second point, 5LR174-151, bears an ambiguous resemblance to a stemmed Type II Scottsbluff point while other attributes are more characteristic of shallow corner-notching. The artifact exhibits some asymmetry in its blade shape, suggesting possible use as a knife or cutting tool. A slight basal indent, not characteristic of the Scottsbluff type, is also apparent. It is unclear if these characteristics are representative of intentional shaping or aberrant attributes from resharpening and retouching. While the point is somewhat smaller than many Scottsbluff points, heavily resharpened points of similar dimensions have been documented (Bonnichsen and Keyser 1982; Joyes 2000). The presence of a confirmed Scottsbluff point at the same site (5LR174-150) further supports that 5LR174-151 may represent a diminutive Type II Scottsbluff form or Scottsbluff-aged tool, though it was ultimately classified as an unassigned Late Paleoindian type.

The remaining Late Paleoindian forms are comprised of a possible Foothills-Mountain Complex point (5LR239-2), an unassigned point (5LR14335-1), and an unassigned preform (5LR240-60). The Foothills-Mountain Complex was defined by Frison (1991:67), and refers to artifacts associated with "foothill-mountain-oriented" groups who occupied the Southern Rocky Mountains in the Late Paleoindian period after 10,000 years ago. Projectile points assigned to this type reflect a high degree of variability, which Pitblado (2007) contends encompasses other better defined Late Paleoindian projectile point types. While debate remains ongoing over the utility of the Foothills-Mountain type, 5LR239-2 does exhibit similarities to representative Foothills-Mountain forms and similar Paleoindian-affiliated points from nearby North Park (cf., Frison 1991: Figure 2.33b-c; Lischka et al. 1983: Figure 7e). There are likewise some similarities with Pryor Stemmed points and associated forms, though these are also not definitive (Benedict 1981; Frison 1991; Pitblado 2003). Ultimately, the point was classified as an unassigned Late Paleoindian type for analytical purposes. 5LR14335-1 and 5LR240-60 were similarly typed as unassigned Late Paleoindian forms. 5LR14335-1 exhibits a basal morphology and flaking pattern which are consistent with Late Paleoindian period technological complexes. The late-stage preform, 5LR240-60, likewise reflects elements of possible Paleoindian manufacture, such as a lanceolate morphology and concave base (LaBelle and Meyer 2017).

While significant variability exists among Late Paleoindian types in the study area, projectile points associated with the Early Archaic (n = 11) are well represented and largely homogenous. Early Archaic diagnostics from the study area are comprised entirely of Mount Albion Complex projectile points (Figure 7). The Mount Albion Complex dates from approximately 4,650 to 4,420 BCE, and is closely associated with the Southern Rocky Mountains of northern Colorado (Benedict and Olson 1978; Benedict 2012; LaBelle and Pelton

2013). The type site for the Mount Albion Complex, the Hungry Whistler (5BL67) site, is located some 70 kilometers (43 miles) to the south of the Rawah Wilderness study area. Projectile points associated with the Mount Albion Complex are comprised of dart points with ground bases and shallow side or corner notches (Benedict 1978). These points are likewise commonly associated with "poor quality" materials, such as vein quartz and quartzite, though smaller quantities of finer materials were also utilized (Benedict 1978:122).

Figure 7. Early Archaic projectile points representative of the Mount Albion Complex. Artifacts 5LR237-178 and 5LR240-2019-27 are produced from CCS, while the remaining examples are manufactured from quartzite.

Mount Albion complex points in the study area assemblages are consistent with examples in Benedict (1978, 2012) and Benedict and Olson (1978) (Figure 7). Quartzite is the most represented material among the Mount Albion points, with a few isolated examples of chalcedony and chert materials (5LR240-2019-27, 5LR237-178, 5LR237-172 [pictured in

Appendix A]). Basal morphology is largely uniform across the Mount Albion assemblage though, consistent with observations in Benedict (1978), there is a small degree of variability in size and notching.

Late Archaic projectile point morphologies are also represented in the Rawah Wilderness assemblages. Typologies associated with the Late Archaic include Pelican Lake projectile points and possible Pelican Lake/Elko forms. Pelican Lake points are associated with the Northern Plains, where they were first recognized by Wettlaufer (1955), however some ambiguities remain surrounding the use of this type in the Southern Rocky Mountain region (Eighmy and LaBelle 1996). These points are characterized by corner-notches which form “sharp points or barbs” at their intersection with the body of the projectile, alongside variable bases which can be straight, concave, or convex (Frison 1991:101; Lee 2012; Wettlaufer 1955). Though questions remain surrounding the type’s distribution and chronology, Pelican Lake forms have been consistently reported in northern Colorado, where they are assigned a regional date of approximately 1,250 BCE to 230 CE (Gooding 1981; LaBelle and Pelton 2013; Pelton et al. 2016; Tate 1999; Todd et al. 2001). The four points classified as Pelican Lake among the Rawah Wilderness assemblages (Figure 8, top row) reflected similar stylistic attributes to specimens identified as Pelican Lake or probable Pelican Lake forms in the northern Colorado region (cf., Pelton et al. 2016: Figure 5d; Todd et al. 2001: Figure 6; Whittenburg 2017: Figure 4.4). Though the specimens are heavily fragmented, the dimensions of each point are likewise consistent Pelican Lake forms.

Three points were identified as representing possible Elko corner-notched or Pelican Lake variants (Figure 8; 5LR229-15, 5LR239-1, 5LR14336-2019-1), though they were classified as unassigned Late Archaic types for the analytical purposes of this study. The points were not assigned a definitive chronological affiliation due to their variable morphologies and because

Elko corner-notched points are commonly regarded as a "wastebasket" type with limited typological utility (Holmer 1986; Page 2017:319). With this caveat, evidence of Elko corner-notched types and Great Basin influence on the point typologies of the Southern Rocky Mountains and Medicine Bow Mountains has been acknowledged by archaeologists (Benedict 1992; Morris et al. 1994; Pitblado et al. 2007). 5LR229-15 exhibits some similarities to Late Archaic corner-notched points identified as Elko forms, but also closely resembles the representative MM4 type in Tate (1999: Figure 5-1). Though its form is distinct, the artifact is heavily reworked and is missing attributes which would facilitate improved classification. Artifacts 5LR239-1 and 5LR14336-2019-1 are both large corner-notched points with deep notches. 5LR14336-2019-1 closely resembles a near identical example from the Fossil Creek site (5LR13041), which was identified as a possible hafted knife or Elko/Pelican Lake variant (cf., LaBelle 2015a: Figure 34). Though only a medial/lateral fragment exists, 5LR239-1 exhibits similar characteristics as 5LR14336-2019-1 and could reflect a similar point morphology, though LaBelle and Meyer (2017) also considered it to represent a possible Paleoindian type.

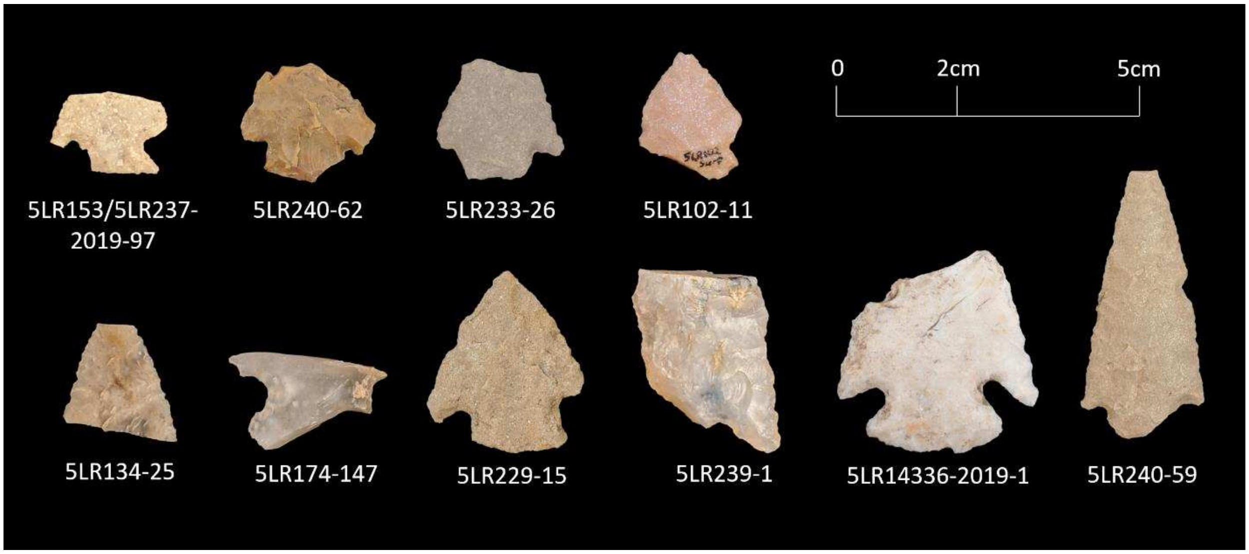


Figure 8. Projectile points representative of the Late Archaic (top row) and unassigned Archaic (bottom row). Artifacts in the top row represent probable Pelican Lake forms. Artifacts in the bottom row are unassigned Archaic forms. Projectile points 5LR229-15, 5LR239-1, and 5LR14336-2019-1 may represent Pelican Lake/Elko variants.

The Late Prehistoric period is also well represented within the wider projectile point assemblage for the study area. Projectile point typologies associated with the Late Prehistoric include Hogback corner-notched, Plains side-notched, Plains tri-notched, and triangular unnotched varieties (Figure 9). Hogback corner-notched points, also referred to as Foothills corner-notched, exhibit deep corner-notches, barbed shoulders, and thin neck widths (Perlmutter 2015). This type was first recognized at the George W. Lindsay Ranch site (5JF11), where Nelson (1971) defined the Hogback Phase. Following Nelson’s (1971) recognition of the points as a distinct type, they have been frequently reported in the foothills and mountains of northern Colorado (Benedict 1975a, 1975b, 1985, 1990, 1992; LaBelle 2015; LaBelle and Pelton 2013; Pelton et al. 2016). Hogback corner-notched points are closely associated with the Early Ceramic period in northern Colorado, and are assigned a date range of CE 600 to 1000 (LaBelle and Pelton 2013). Plains side-notched (5LR238-148) and Plains tri-notched (5LR174-148) are also examples of distinct Late Prehistoric types which are common in northern Colorado. These types are respectively associated with the Middle Ceramic period and Late Ceramic (Protohistoric) period (Gilmore 1999; LaBelle and Pelton 2013). Morris et al. (1994) argue that the observed Plains tri-notch point is representative of Late Ceramic precontact use of the Medicine Bow Mountains, and not the Protohistoric era, and this assertion is supported by the occurrence of Plains tri-notch styles in assemblages which pre-date the Protohistoric period (Butler 1988; Gilmore 1991, 1999; Nelson and Stewart 1973). Both Plains side-notched and Plains tri-notched types have likewise been identified in high elevation contexts (Benedict 1985; LaBelle and Pelton 2013). Regional dates for these points range from CE 1,100 to 1,800 for Plains side-notched varieties to CE 1,600 to 1,800 for Plains tri-notched types (LaBelle and Pelton 2013).

Figure 9. Representative Late Prehistoric forms. Top row, from left: A proximal/medial fragment of a Hogback Corner-notched arrow point, a proximal/lateral fragment of a Hogback Corner-notched projectile point, a Plains Side-notched projectile point, and a Plains tri-notched point. Bottom row: Triangular unnotched projectile points.

Triangular unnotched points are also present among the Late Prehistoric diagnostics (Figure 9). These points are often affiliated with the Middle and Late Ceramic, and can occur in a number of temporal contexts across these periods (Gilmore 1999; Johnston 2016; Meeker 2017). Triangular unnotched points are distinguished from projectile point preforms, such as the "guitar pick[…]" preforms associated with the Early Ceramic period, by their thinned cross-section and finished base (LaBelle 2015:40; Meeker 2017). These points are found in the plains and foothills of Larimer County, as well as at high elevations in the Colorado Front Range (Benedict 1985; Johnston 2016; Meeker 2017). Unnotched triangular points often co-occur with Plains side-notched and Plains tri-notched varieties, and there is evidence for their contemporaneity at the Roberts Buffalo Jump (5LR100) and upper occupation level of the Caribou Lake site (5GA22) (Benedict 1985; Johnston 2016).

Bifaces

Bifaces (n = 61) comprise the bulk of the tool assemblage considered in this study, representing 30.7% of the total tools evaluated among the collections. Bifaces were classified as artifacts which exhibit modification on two-faces of a single flaked edge around at least half of the artifact (Andrefsky 1998). No distinction was made for the stage of biface manufacture for this study, due to time constraints which limited the analysis of a large legacy collection, and a wide degree of variability exists in the size and characteristics of artifacts associated with this class (Figure 10). Five of the artifacts in the biface assemblage were recovered in the field in 2019 by Buckner (2019), while the remaining 56 are associated with collections by Morris et al. (1994) and Metcalf (1971a). The majority of bifaces were produced from CCS materials (n = 52), with smaller frequencies of quartzite (n = 9). Varying stages of completion and preservation are apparent in the assemblage, with just six complete bifaces among all artifacts examined. Dimensions and characteristics of the full biface assemblage are available in Appendix B.

Also present among the biface assemblage were "big knives", which Morris et al. (1994) considered a distinct tool type (Figure 11). Morris et al. (1994) suggested these artifacts were associated with the Paleoindian period, though they were not assigned any temporal affiliation in this study. Morris et al. (1994) similarly identified these artifacts as large scrapers, though laboratory study for this analysis found them to be most consistent with large bifacial blanks. The artifacts were manufactured from gray quartzite and were transported into the study area as large flake blanks. There is likewise some resemblance to the large edge modified flakes discussed later in this chapter (See Figure 17). 5LR131-90 consists of a mended refit between sites 5LR131 and 5LR273, a straight-line distance of approximately 740 meters (Figure 11).

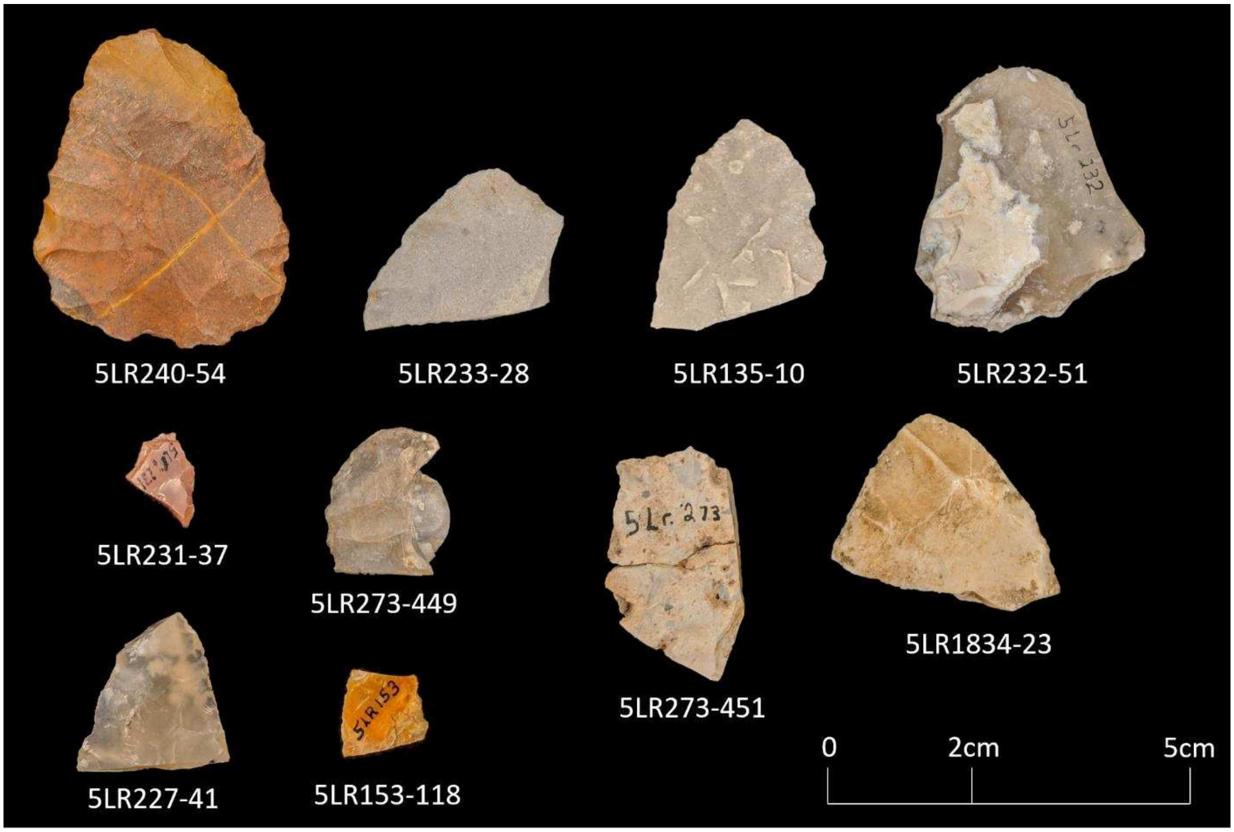


Figure 10. A representative sample of variability in biface forms among the WBLR watershed assemblages. Various morphologies, material types, and stages of reduction are represented.

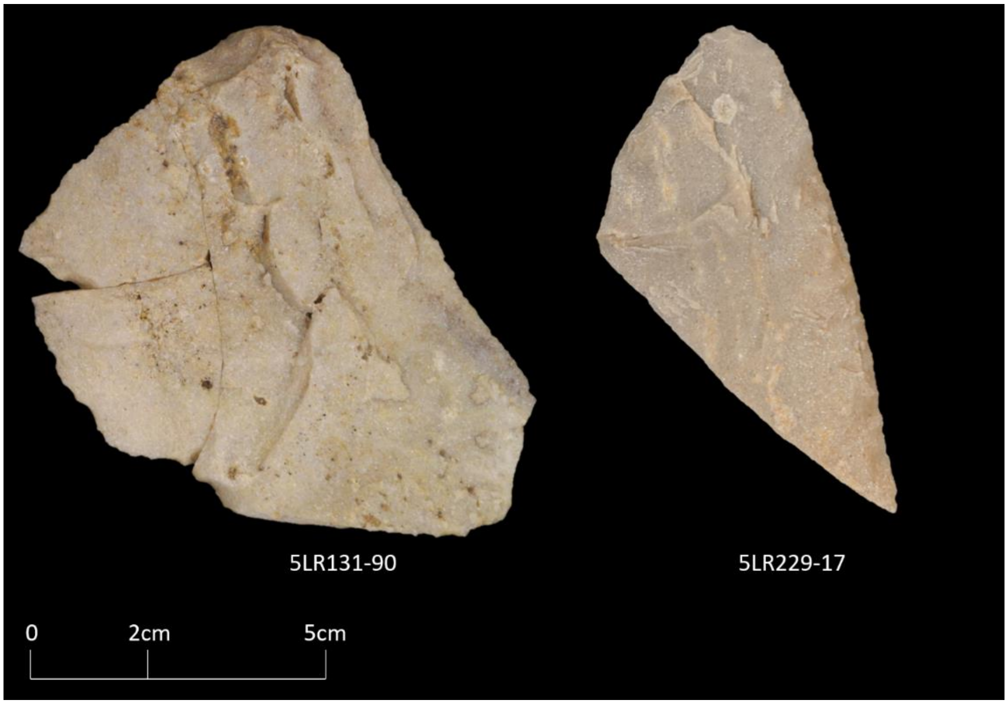


Figure 11. Examples of "Big Knives", as defined in Morris et al. (1994). Artifact 5LR131-90 consists of a mended refit between 5LR131 and 5LR273, a straight-line distance of approximately 736 meters.

Drills

Drills (n = 3) account for just 1.5 % of the total assemblage and are little represented among the Rawah Wilderness collections. The three specimens identified among the WBLR assemblages include one complete winged drill and two drill fragments (Figure 12). For the purposes of this analysis, drills were defined as rotationally exerted perforating tools with a formally worked bit (Andrefsky 1998). 5LR17-4 is the most complete drill form and is comprised of a large 'T' shaped drill manufactured from white chert (Figure 12). The remaining artifacts are in fragmentary condition, including the medial fragment of a drill base and bit manufactured from chalcedony (5LR225-21), and a proximal fragment of an obsidian drill with a cylindrical base (5LR225-23). 5LR225-21 was refitted and glued at an indeterminant time following its collection between 1971 and 1996 and was recorded as a single artifact. 5LR225-23 is the only documented obsidian tool associated with the study area and is finely flaked with a narrow bit. All artifacts are bifacially worked.

Figure 12. The complete sample of drills among the WBLR watershed assemblages. From left: A complete T-shaped drill, a proximal/medial fragment of a drill bit and base, and a base fragment of an obsidian drill.

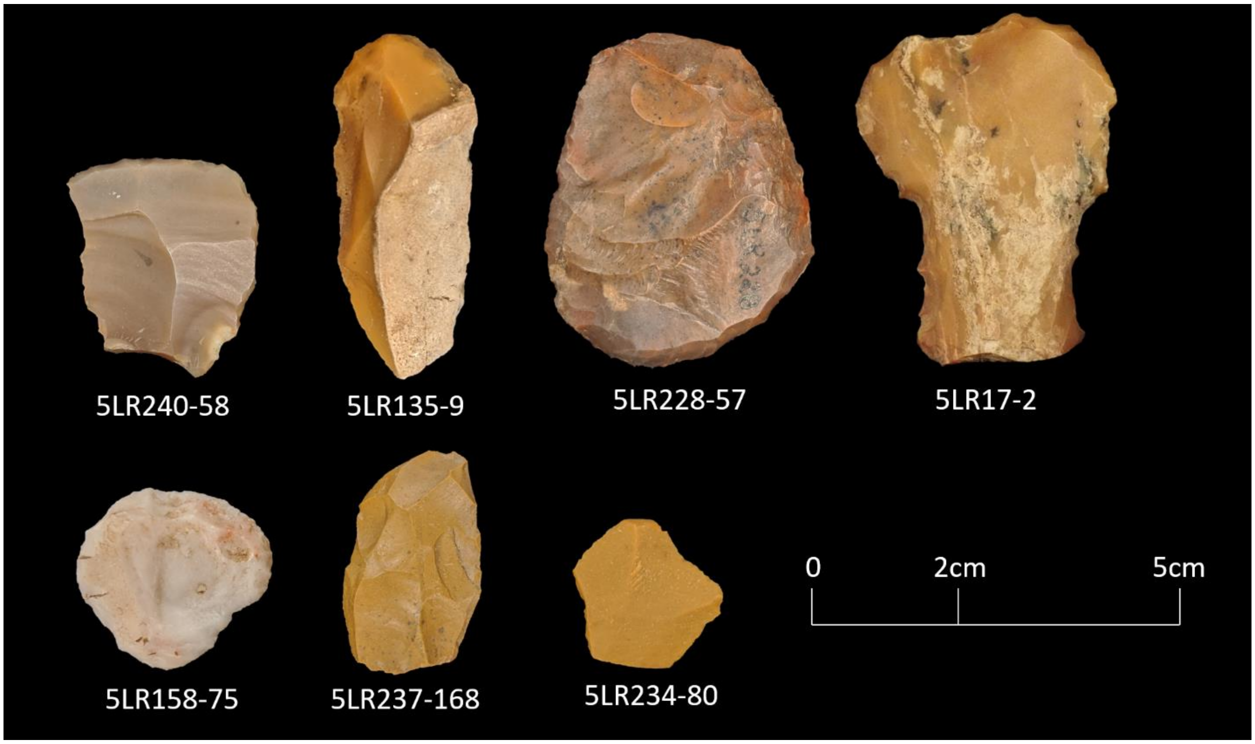


Figure 13. A representative sample of scrapers among the WBLR watershed assemblages. There is substantial variability in morphology and material types across the wider scraper assemblage.

Scrapers

Scrapers (n = 18) occur in moderate quantities in the WBLR assemblages, representing 9.1% of the total, and these tools exhibit a high degree of morphological and functional variability. Scrapers were defined as flake tools with formal high angle retouch along at least one margin (Andrefsky 1998). No class distinction was made between end- and side-scrapers, due to time constraints which limited the analysis of a large legacy collection, and substantial diversity exists in the size and character of artifacts associated with this category (Figure 13). Some examples appear to represent hafted scrapers, such as 5LR17-2, while others reflect expedient use as thumbnail scrapers (5LR234-80). Discoidal scrapers are also present among the assemblage, showing more intensive retouch and formal shaping (5LR228-57, 5LR158-75). Scrapers in the assemblage are largely produced from chert varieties, with only one example of an expediently utilized quartzite scraping tool (5LR174-157, See photograph Appendix A). Half of the scrapers in the assemblage are complete (n = 9), which reflects a much higher rate of intact discard than other tool classes. The high incidence of complete scrapers may be attributable to the heightened probability of their accidental discard during butchery and processing activities or, more likely, due to the selection of sturdy flake blanks for their manufacture.

In some cases, Morris et al. (1994) identified scraper subtypes as diagnostic tools. The Big Knives discussed previously, for example, were classified as scrapers diagnostic of the Paleoindian period. Similarly, Morris et al. (1994:70) referenced “beaked end scrapers” as an additional type which was considered diagnostic of this period. For this study, no temporal affiliation was assigned to any scraping tool, and Big Knives were found to be more consistent with the biface tool class.

Cores

Cores occur in small quantities (n = 4) among the study area assemblages, a paucity likely attributable to the absence of local materials. While assemblages with large quantities of cores would be expected in proximity to procurement areas, the composition of tool assemblages in the study area suggest raw materials were reduced to preforms or large bifacial blanks before being transported to the high elevations of the Medicine Bow Mountains (Morris et al. 1994). Accordingly, the scarcity of these artifacts supports Morris et al.’s (1994) determination that materials were transported into the area over long distances.

For the purposes of this study, cores were defined as the objective “nucleus” from which flakes were removed for production of formal and informal tools (Andrefsky 1998: xxii). Many artifacts, which perhaps started as cores in the early stages of the reduction process, were likely utilized and used to produce formal tools themselves. Recognizing this, the core classification refers only to those tools which were discarded following their use for flake blank production. Cores in the Rawah sample are primarily manufactured from CCS, including cherts (5LR240-55, 5LR233-32) and chalcedony (5LR174-146), with one additional core produced from quartz (5LR101-16). The WBLR cores are multidirectional and bifacial, discoidal in shape, and exhibit varying degrees of preparation. 5LR233-32 is characterized by a well-defined discoidal shape with preserved cortex coverage. 5LR174-146, which reflects a less formal reduction pattern, likewise retains a large amount of cortex coverage. The remaining cores, 5LR240-55 and 5LRLR101-16, are without cortex. All cores in the study appear to be exhausted or nearly exhausted, though 5LR101-16 is significantly more reduced than examples pictured in Figure 14. Dimensions and characteristics for each artifact are reported in Appendix B.

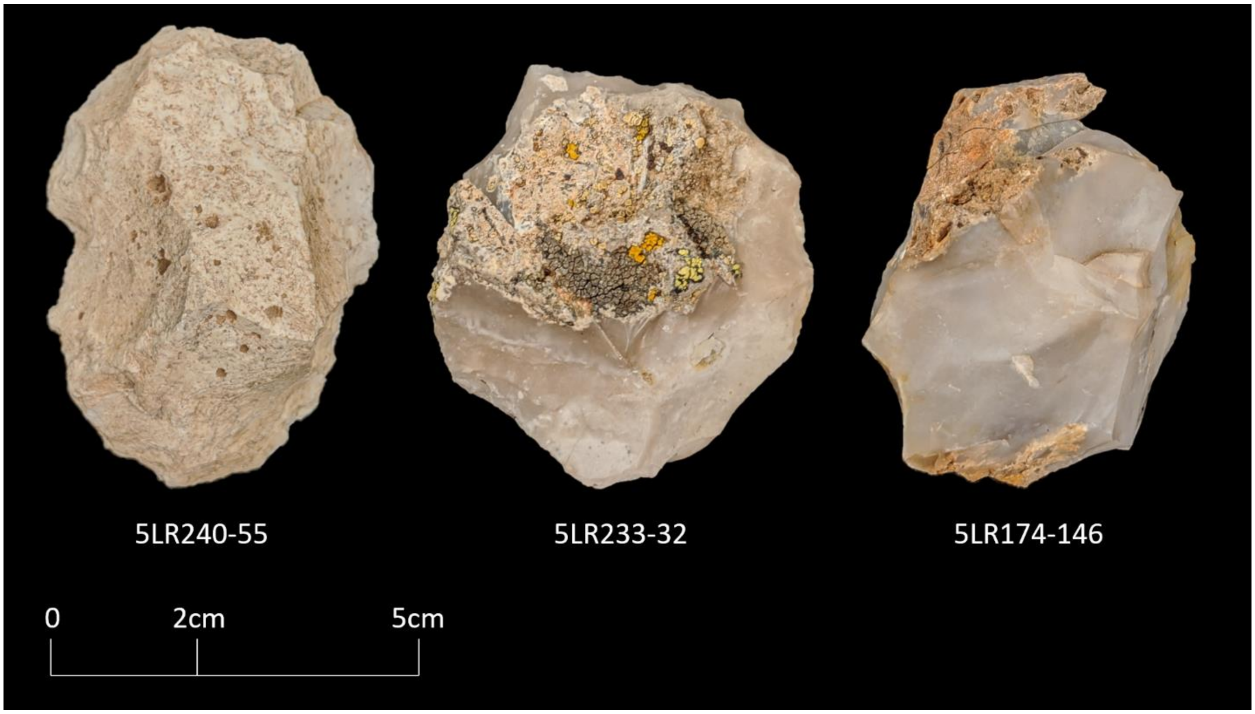


Figure 14. A sample of lithic cores among the WBLR watershed assemblages. All cores reflect a discoidal shape and were bifacially reduced. Two of the artifacts retain cortical material on their surface. There appears to be some variability in the reduction type for each core, but all exhibit multidirectional flaking. One additional quartz core (5LR101-16) is pictured in Appendix A. All dimensions and metrics are provided in Appendix B.

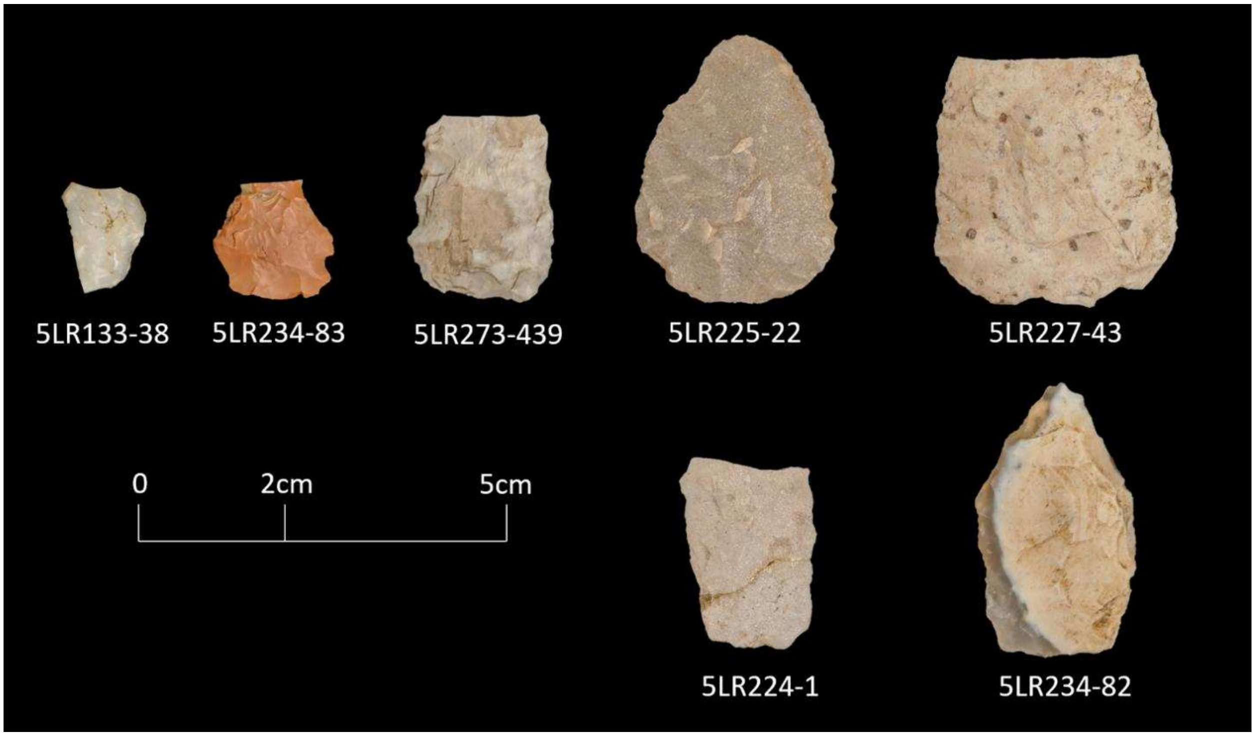


Figure 15. Variability in preform morphology across the study area assemblages. A high degree of diversity is apparent in the morphology and raw material selection for production of preforms. Additional examples of preforms are pictured in Appendix A. All dimensions and characteristics are provided in Appendix B.

Preforms

Artifacts designated as preforms (n = 17) account for 8.5% of the total tool assemblage and were defined as a nearly completed stone tools which exhibit recognizable elements of the tool's probable final form. In the case of preforms from the WBLR assemblages, this is mostly distinguished by characteristics which are indicative of the final stages of the reduction process, such as thin cross-sections and fine flaking (Figure 15). A high degree of variability exists among the preform assemblage, both in material, type of manufacture, and morphology. Only one preform (5LR240-60), pictured previously in Figure 6, was assigned a temporal affiliation. Given that the remaining preforms represent the production of many types of tools through time, largely assumed to be projectile points though this is not always the case, the diversity in their morphologies is expected. Observed preforms include artifacts produced from both CCS (n = 9) and quartzite (n = 4). Representative quartzite artifacts include 5LR225-22 and 5LR224-1. 5LR225-22 is a finely prepared ovate preform, which was lost or discarded in complete condition. Evidence of reddening and the development of pot-lids on the anterior surface of the artifact indicates it was exposed to high temperatures, through it is unclear if this is the result of natural or cultural processes. 5LR224-1 is a lanceolate shaped preform and a refit mended sometime after its collection between 1971 and 1996. Preform fragments, such as 5LR133-38 and 5LR234-83, are also present in the assemblage. These fragments were difficult to discriminate from projectile points and other formal tools, however they were distinguished by the absence of any evidence of resharpening, defined use-wear, and other morphological characteristics which would suggest a functionally complete tool.

Ground Stone

The ground stone assemblage (n = 8) comprises two tool classes, handstones (n = 1) and netherstones (n = 7). Handstones were defined as handheld tools which were used to actively process items against a passive surface, through a grinding or battering motion (Adams 2002). Netherstones, in contrast, are the static surface against which items are ground or battered (Adams 2002). These terms are used in lieu of 'mano' or 'metate' to better reflect the morphologies of common ground stone artifacts in the northern Colorado region, which typically are not consistent with the formally shaped grinding tools described in the Southwestern literature (Adams 2002; LaBelle and Pelton 2013; Pelton 2013). One exception for the high elevations of the Rocky Mountains is the basin metate reported by LaBelle and Pelton (2013: Figure 10), though no comparable examples were identified among the Rawah Wilderness assemblages.

The single handstone (5LR102-10) identified in the Rawah Wilderness ground stone assemblage is comprised of a river cobble, which appears to be consistent with the area geology and may have been locally procured. Netherstones, by contrast, were produced from tabular fragments of tan and red sandstone (Figure 16). Two examples, 5LR233-33 and 5LR17-6, are complete or nearly complete, while the remaining artifacts represent fragments of smaller slabs. The sandstone used to produce the netherstones resembles Lyons formation varieties, which were quarried among the hogbacks of the eastern foothills of the Front Range (Morris et al. 1994; Kvamme 1977; Shropshire 2003). The presence of this sandstone at the high elevations of the Rawah Wilderness, into the alpine ecozone in some cases, suggests that netherstones were carried from the lower elevations of the foothills some 60 kilometers (40 miles) away. The transport of sandstone grinding implements into the high country is consistent with trends identified by Benedict (1992) and Pelton (2013, 2017). There are, however, inconsistencies between patterns of ground stone use observed in the Colorado Front Range and the Medicine Bow Mountains. In the high elevations of the Indian Peaks Wilderness, for example, 40% of sites were associated with ground stone artifacts (Pelton 2017). In the Rawah Wilderness assemblages, by contrast, ground stone was present in fewer than 17% of site assemblages.

Variability among netherstones is difficult to recognize given the fragmented nature of most specimens. Some of the netherstones exhibit evidence of burning or sooting, notably 5LR17-6 and 5LR240-2019-29 (pictured in Chapter 6, Appendix A). Evidence of pecking is also apparent on some surfaces, such as on the grinding surface of 5LR17-6 and 5LR133-40. Generally, ground stone artifacts from the WBLR are lightly ground and without formal shaping or concavity. Grinding surfaces are more apparent on some netherstone artifacts than others, though all show evidence of grain shearing on at least one surface.

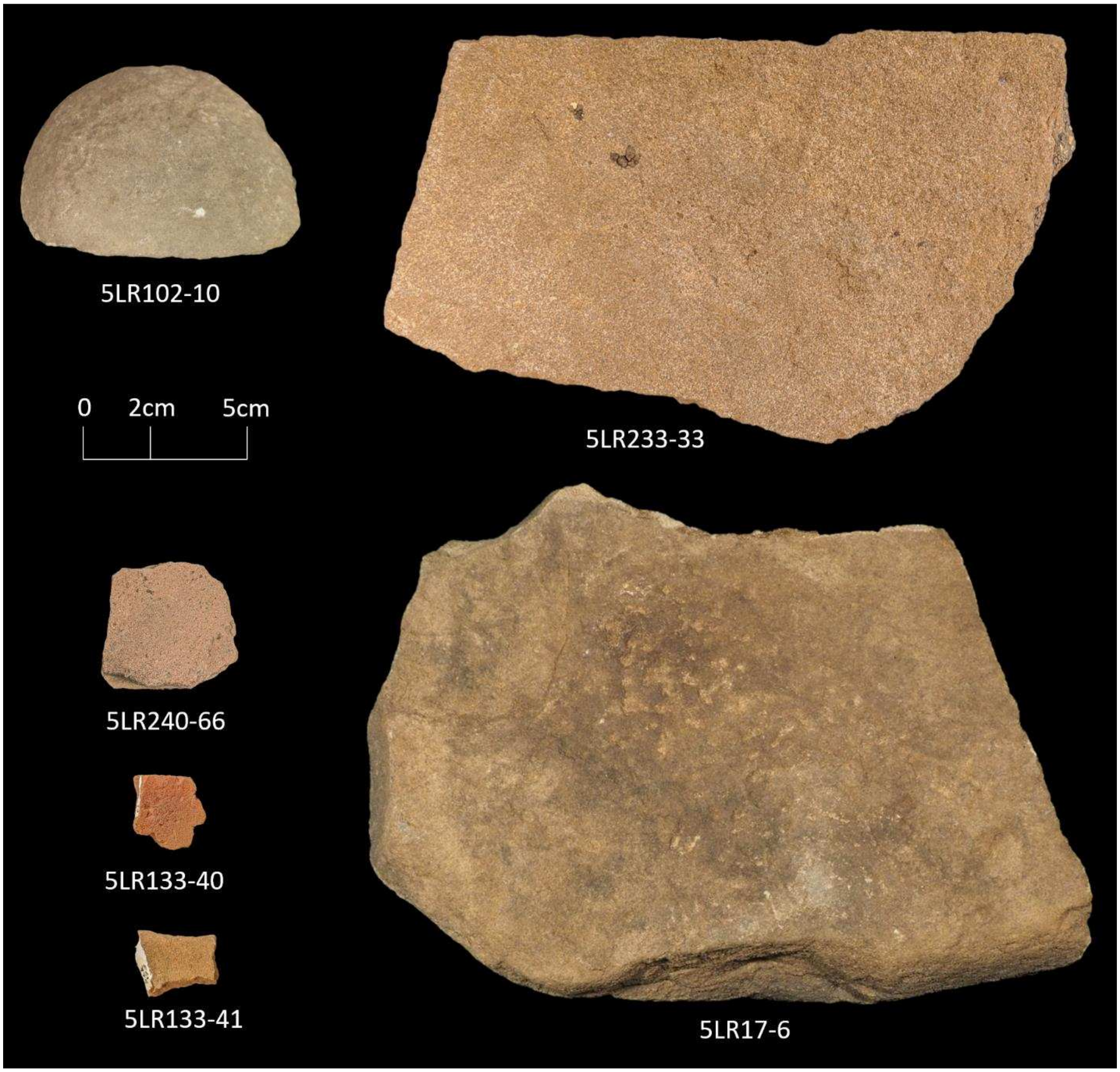


Figure 16. A sample of ground stone artifacts among the WBLR watershed assemblages. Only a single handstone fragment (top left) has been recovered from sites within the study area. Netherstones and netherstone fragments, which comprise the majority of the ground stone assemblage, resemble sandstone acquired from quarries in the foothills ecotone of the Colorado Front Range (Kvamme 1977; Pelton 2013, 2017; Shropshire 2003). Additional examples of ground stone artifacts are pictured in Appendix A. All dimensions and characteristics are provided in Appendix B.

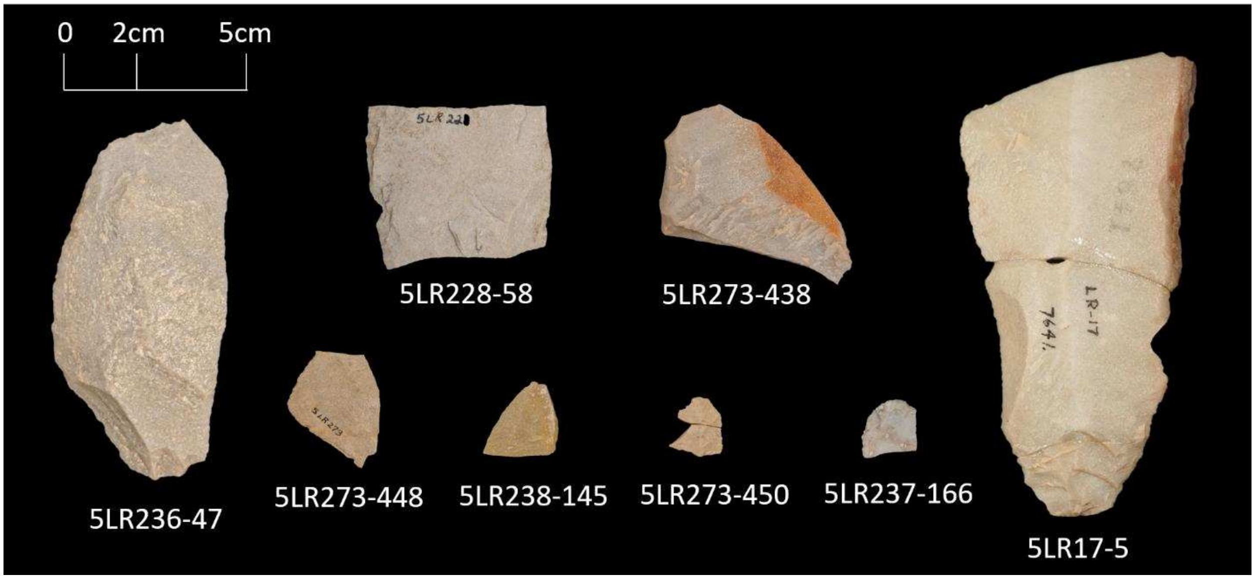


Figure 17. A representative collection of edge modified flakes from the study area. Edge modified flakes range from large blanks with light retouch (Top row, including 5LR17-5, 5LR236-47) to expediently made cutting tools (Bottom row). Additional examples of edge modified flakes are pictured in Appendix A. All dimensions and characteristics are provided in Appendix B.

Edge Modified Flakes

Edge modified flakes (n = 26) were among the most common tools in the WBLR watershed assemblages, representing 13.1% of the total. Edge modified flakes were defined as informal tools produced through expedient retouch of flake debitage (Andrefsky 1998). In many cases, this tool class is represented by small biface thinning flakes with marginal retouch. In other instances, large flake blanks also exhibit evidence of varying degrees of informal marginal retouch (Figure 17). These tools were produced from both CCS (n = 16) and quartzite (n = 10) and reflect significant variability in their completeness and preservation. Regardless of size, however, both complete (n = 12) and fragmented artifacts (n = 14) reflect similar levels of expedient modification. Examples of waste flakes with marginal retouch represent short use life tools which were almost certainly rapidly discarded. Larger flake blanks, although exhibiting similar degrees of expedient retouch, likely had longer use lives and were curated as part of a lithic raw material conservation strategy. The presence of large quartzite flake blanks with marginal modifications is likewise reminiscent of Morris et al.'s (1994:70) "Big Knives", which were classified as bifaces for this study. At least two examples of edge modified flakes in the Rawah collections are comprised of mended refits (5LR273-450 and 5LR17-5).

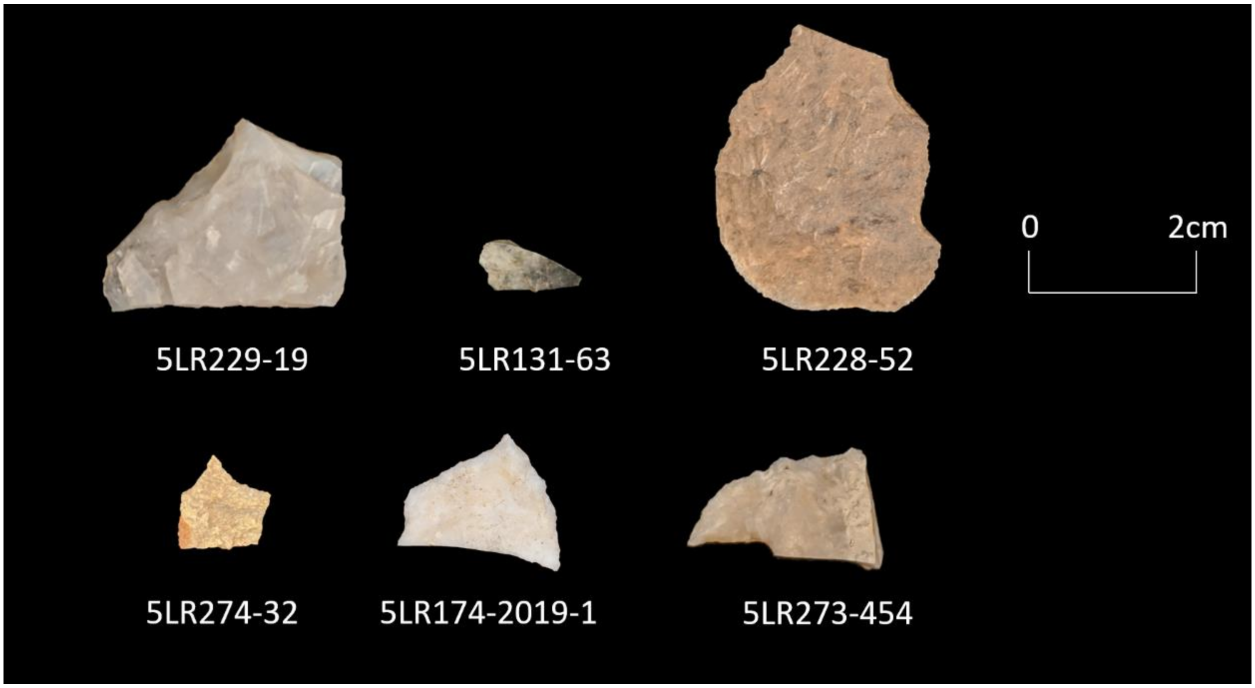


Figure 18. All unifaces (top) and gravers (bottom) among the WBLR watershed assemblages. Both tool classes were infrequent among the larger assemblage. All dimensions and characteristics for each tool are provided in Appendix B.

Unifaces and Gravers

The final two tool classes, unifaces (n = 3) and gravers (n = 3), are specialized tool types which occur in small quantities among the Rawah assemblages, each representing just 1.5% of the total number of tools. Unifaces were defined as flake tools which exhibited modification "on either the dorsal or ventral surface only" (Andrefsky 1998: xxvii). The function of these tools is highly variable and they were assigned to the uniface class based on their physical characteristics rather than any apparent functional purpose. In fragmented form, they could represent miscellaneous flake blank tools which only required reduction of the dorsal surface to meet the needs of the tool user. Gravers, in contrast, have a more explicit functional association. Graving tools were classified as artifacts with a prepared pressure-flaked tip which was used to incise various materials, such as bone or wood. These tools can be identified by fine pressure flaking and shaping associated with a graving tip which tapers to a sharp point (Figure 18). In cases, these tools can be expediently modified in a manner similar to an edge modified flake, though they take a more formal form in other instances. 5LR174-2019-1, for example, exhibits evidence of formal bifacial flaking in association with a well-defined graving tip.

Lithic Debitage

In addition to tools, an extensive collection of lithic debitage is associated with the Rawah Wilderness collections. Metcalf (1971a) and Morris et al. (1994) collected surface debitage from sites they investigated, though four site assemblages were comprised only of isolated tools and no lithic debitage. Similarly, the surface sample of artifacts from 5LR17 does not contain any debitage. While Morris et al. (1994) applied a sampling strategy which included collection of debitage, collections from 5LR17 were limited to tools (Wheat 1947).

In total, 2,199 pieces of debitage were analyzed for this study. Debitage was classified into two categories, flakes and angular debris. Flakes were defined as the "portion of rock removed from an objective piece by percussion or pressure" which exhibit evidence of a ventral surface, striking platform, and bulb of percussion (Andrefsky 1998: xxiii). Though the proximal portion of a flake may be missing, artifacts were still classified as flakes if there was clear evidence of a distal-proximal orientation with clear ventral and dorsal surfaces, as well as a cross-section which was consistent with the removal of the artifact from an objective piece. Angular debris, by contrast, was defined as the miscellaneous fragments or shatter produced during the reduction process which lack attributes diagnostic of flakes, such as the bulb of percussion or striking platform (Andrefsky 1998). Flakes (n = 2,080) comprised the vast majority of the debitage assemblage, representing 94.6% of the total, while 5.4% of debitage artifacts were classified as angular debris (n = 119).

Each debitage artifact was physically inspected, and a number of descriptive attributes were recorded for each item. These attributes include size class, which corresponds to the maximum length of each artifact. A size class of one describes a maximum length of 0 to 1cm, a size class of two indicates a length of 1cm to 2cm, and so on. Also recorded was presence/absence of heat treatment or thermal alteration, cortex, and a striking platform. Portion and lithic raw material type were also documented. Thermal alteration was defined by the presence of crazing, potlids, or significant reddening and change in coloration. Presence of cortex was recorded by examining artifacts for any cortical material, and no minimum percentage cortex coverage baseline was employed. The presence/absence of a striking platform was documented by inspecting each flake for evidence of an existing platform, associated platform preparation, and/or a bulb of percussion. A small number of obsidian flakes (n = 4) had been removed from the collection for sourcing analysis, and attributes were not documented for these items (LaBelle 2009; Jason LaBelle, personal communication 2018).

The results of the debitage laboratory analysis demonstrates that a high degree of variability exists among the assemblage. Size class 1 (n = 676) and size class 2 (n = 999) debitage artifacts comprised 76.2% of the total amount of debitage, demonstrating that Morris et al.'s (1994) sampling strategy was successful in identifying small artifacts. Larger size classes, such as size class 3 (n = 374) and size class 4 (n = 116), occurred at smaller frequencies. The largest flakes, size class 5 (n = 27) and size class 6 (n = 3), comprised a negligible amount of the total lithic debitage assemblage. Alongside the predominance of non-cortical flakes (n = 1,898; 86.3%) over cortical flakes (n = 297; 13.5%), this pattern again supports the conclusion that no sources of lithic raw materials exist in the study area. If a significant source of toolstone was local to the study area, we would expect to see larger quantities of debitage with a higher size class, representing primary stages of reduction, as well as a higher proportion of cortical materials (Bamforth 2006). Instead, these findings support Morris et al.'s (1994) assertion that lithic raw materials were overwhelmingly imported to the WBLR watershed as finished tools or previously reduced blanks.

Other attributes of the lithic debitage assemblage include the presence/absence of thermal alteration or heat treatment, and the presence/absence of a defined striking platform. Thermal alteration data was collected to evaluate patterns in the heat treatment of lithic raw materials, however evaluation of heat treatment can be problematic when working with surface collections given their probable exposure to a regular fire regime through time. With this caveat, just 123 (5.6%) debitage artifacts exhibited characteristics of thermal alteration or heat-treatment, compared to 2,072 artifacts which were unaltered (94.4%). Similarly, a striking platform was observed on 667 (30.4%) artifacts, which was largely consistent with the overall combined percentage of complete flakes and proximal fragments of flakes (28.3%). Additional analyses of debitage assemblages from the WBLR can yield insights into the intensity and modes of lithic reduction which were practiced in the study area, but this level of analysis was outside the scope of the present study.

Discussion

The descriptive analysis of existing assemblages from the WBLR study area demonstrates both the temporal and functional diversity of lithic artifacts from these high elevation contexts. These datasets offer a useful opportunity for investigation of the change in ancient people's use of this landscape through time. Though the analysis of projectile point typologies shows that surface collections from the Medicine Bow Mountains are time-averaged, the artifact composition of these mixed assemblages represents a valuable dataset for the study of persistent places from a long-term perspective (Shiner 2009). Though these materials are provenienced only to the site level, as they were collected prior to the widespread availability of high-quality GPS equipment, they retain enormous data potential.

The functional variability among tools from the study area, alongside the heterogeneity of lithic raw materials, likewise reinforces the potential of the Rawah datasets to study the long-term land use practices of ancient Native Americans in the northern Colorado region. Variability among tool function and lithic raw materials offers a window into the cumulative use of a place through time, and can be used to determine if these uses were homogenous or heterogenous over these extended temporal scales. Collectively, this descriptive analysis demonstrates that the existing collections from the WBLR study area retain substantial analytical value for the study of ancient hunter-gatherers' use of high elevation landscapes. Particularly for this study, the time-averaged nature of these collections is uniquely suited for addressing questions surrounding reoccupation and the persistent use of place. This chapter's analysis of the archaeological record of the Rawah Wilderness, and the variability reflected in these assemblages, underscores the suitability of the WBLR sample and the potential for these datasets to the clarify the functional and temporal dynamics of ancient peoples' use of the Medicine Bow Mountains.

CHAPTER 3 – DEVELOPING EXPECTATIONS FOR PERSISTENT REOCCUPATION

Prior to implementation of any archaeological research design, it is necessary to outline the underlying theory and expectations which form the foundation of the analysis. While the previous chapter described the chronology and material culture of the study area, as reflected through extant collections, the objective of this chapter is to define the theoretical basis for the analysis and contextualize the research design within the broader state of knowledge surrounding the archaeology of the Southern Rocky Mountains. To explore these themes, the chapter begins with a concise overview of high elevation archaeology in northern Colorado, followed by a discussion of theoretical and methodological considerations for understanding reoccupation and the persistent use of place. The chapter then concludes by outlining expectations for the assemblage composition, landscape distribution, and spatial structure of reoccupied sites. By establishing these a priori baselines for the physical and spatial manifestation of high reoccupation intensity in mountain environments, the chapter will lay the groundwork for the analyses conducted in the subsequent chapters.

High Elevation Archaeology of the Colorado Front Range and Medicine Bow Mountains

The Southern Rocky Mountains of northern Colorado are associated with a rich archaeological record representing at least 10,000 years of intensive human use (Benedict 1992; Brunswig 2007; Morris 2010). The material traces left by these activities remain readily apparent on the landscape today and visitors to the Colorado high country are likely to encounter these ancient artifacts and features, whether they are aware of them or not, surrounding the high passes and alpine lakes which draw recreationalists to these areas today. The indigenous use of these environments was so extensive that the large quantities of ground stone artifacts these peoples transported into the upper elevations of the Colorado Front Range were once mistakenly attributed to natural sandstone deposits originating from geologic processes (Ives 1942). These mountain environments offered hunter-gatherers many high-value resources and subsistence opportunities which served to draw people into the high country on a seasonal basis. Alpine residential sites elsewhere in the Rocky Mountains and Sierra Nevada, for example, have yielded evidence of the systematic exploitation of fauna and flora for subsistence purposes (Adams 2010; Bettinger 1991; Morgan 2012). In Colorado, the iconic game drive systems of the Colorado Front Range exhibit evidence of communal organization for procurement of faunal resources (Benedict 1992, 1996; LaBelle and Pelton 2013). Research on high-elevation prehistory in Colorado has also emphasized the seasonal availability of alpine flora as a source of subsistence for indigenous peoples, which is reinforced by the large quantities of ground stone found at high elevations in the Colorado Front Range (Benedict 2007; Pelton 2013, 2017). The systematic precontact utilization of Colorado's Rockies is also evidenced by the intensive high elevation quarrying of raw materials for tool production, such as at the Windy Ridge quartzite source (Bamforth 2006; Black and Theis 2015; Mitchell 2012). Collectively, this evidence for the intensive use of high elevation landscapes demonstrates that the ancient inhabitants of Colorado's mountains were not simply passersby in these environments, but agentive actors who left indelible marks on the landscape.

While the archaeological record of high elevation contexts in the Wind River Range and Sierra Nevada is characterized by the discovery of long-term residential occupations, the Colorado Front Range is defined by its "distinct form of residential settlement" which emphasized highly mobile seasonal transhumance systems and short-term camps associated with resource procurement (Pelton 2017:1). While the record of the Medicine Bow Mountains reflects some similarities to these patterns, it also exhibits significant contrasts. For example, Benedict's (1992) rotary transhumance system relies on the spring passage of low passes in the Medicine Bow Mountains, including Cameron Pass (ten kilometers south of the study area). If the Medicine Bow Mountains are a component of this larger annual round, as Benedict (1992) suggests, the archaeology of the two ranges is inexorably tied.

Research on the role of the Medicine Bow Mountains in larger transhumance systems is inconclusive, though Morris et al. (1994:74) observed that lithic raw materials were imported a "considerable distance" from their sources. Similarly, Morris et al. (1994) describe Great Plains and Great Basin influences in the projectile point typologies identified among the Rawah Wilderness site assemblages. Though these lines of evidence require additional analysis to reconstruct any definitive patterns of transhumance, such as the systems proposed by Benedict (1992), by examining the archaeological record of both ranges these analyses can clarify how the Medicine Bow Mountains fit with the larger regional systems of northern Colorado. The alpine game drives, for which the Colorado Front Range is well known, do not exist in the Medicine Bow Mountains (Benedict 1992; Metcalf 1971a; Morris et al. 1994). Similarly, though Pelton (2017) identified ground stone artifacts at 40% of high elevation sites in the Colorado Front Range, and described a landscape-scale system of ground stone provisioning for intensive plant processing, ground stone artifacts occur in fewer than 17% of assemblages considered in this study (See Chapter 2).

These discrepancies in landscape use and subsistence between the Medicine Bow Mountains and the Colorado Front Range point to substantive differences in forager groups' utilization of the two ranges. While the Colorado Front Range reflects evidence of the intensive utilization of alpine flora, alongside a highly organized and community-driven hunting infrastructure, the record of the Medicine Bow Wilderness exhibits evidence of a different level of social organization, subsistence emphasis, and settlement strategy. In Benedict's (1992) rotary system for the Late Prehistoric period, these differences could be attributable to the dispersal and aggregation of "microbands" and "macrobands" during different phases of the seasonal round, and this model suggests occupation of the Medicine Bow Mountains largely occurred during these periods of dispersal rather than aggregation. Morris et al. (1994:67) similarly speculate that occupation of the Medicine Bow Mountains was limited to "generally small" groups. Alongside little evidence of any community aggregation, in contrast to the Colorado Front Range, Morris et al.'s (1994) assessment generally aligns with Benedict's (1992) supposition that the seasonal movement of people into the Medicine Bow Mountains was principally characterized by microbands during these periods of dispersal in the spring and early summer.

Additional research is required to clarify these contrasts in landscape use between the Medicine Bow Mountains and the Colorado Front Range, and to better understand the broader systems of human landscape use in the northern Colorado region over a larger time span. While Benedict's (1981, 1985, 1990, 1992, 1996, 2000) prolific research program in the Colorado Front Range produced a wealth of invaluable data for evaluating these trends, additional research is required from the Medicine Bow Mountains to fully investigate the similarities and differences between the indigenous use of these landscapes. Analysis of reoccupation, and its implicit connections to the long-term "social investment" in mountain landscapes, is one interpretive avenue with the potential to lay a foundation for investigating these issues (Morgan et al. 2018; Scheiber and Zedeño 2015:1).

Persistent Places, Palimpsests, and the Study of Reoccupation

Study of reoccupation and the reuse of place is critical to understanding broader trends in landscape use, mobility, subsistence, and settlement. There is a clear distinction between sites which have been repeatedly and preferentially reused through time and sites which were used once and abandoned. Clarifying *why* some areas of the mountains, over others, were the subject of persistent reuse can inform broader understanding of human agency and ancient peoples' perceptions of high elevation landscapes. Was persistent reoccupation simply the result of optimal environmental conditions for hunting and foraging? Or perhaps a cultural connection to the place reinforced by visible artifactual traces of past use? A framework for addressing these questions is the persistent place concept (Schlanger 1992). Persistent places are defined as "places that were repeatedly used during the long-term occupations of regions" which played significant "long-term roles in local land use patterns" (Schlanger 1992:97,110). As the "conjunction of particular human behaviors on a particular landscape" persistent places are likewise not as limited by the constraints of the site concept, and instead offer a broader interpretative framework for consideration of the complimentary roles of landscape, place, and space (Dunnell 1992; Schlanger 1992:97).

Though Schlanger's (1992) original application of the persistent place concept was focused on agriculturalist populations in the American Southwest, there has been growing application of persistent place studies to hunter-gatherer contexts (Dooley 2004, 2008; Gamble 2017; Morgan 2018; Shiner 2009; Zilio and Hammond 2017). Similarly, though there is an increasing discourse in the Southwestern literature over the challenges of discriminating *persistent* places from *permanent* places, the persistent place concept has proven well suited for study of seasonal transhumance and mobility in hunter-gatherer landscape use (Clark and Gilman

2012; Shiner 2009). Given the broad chronological focus of persistent place studies, which are concerned with long-term trends rather than fine-grained study of isolated events, applications of the persistent place concept are generally oriented towards analyzing reuse with broad temporal resolution (Dooley 2004, 2008). Schlanger's (1992) initial study was aided by the chronological resolution offered by tightly dated ceramic typologies in the American Southwest, however, persistent place analyses based solely on projectile point typologies necessitate a broader temporal approach. The persistent place concept has likewise been applied with great effect to the analysis of time-averaged contexts, which investigate the degree to which "remains from succeeding occupations are mapped onto or acknowledge remains from preceding occupations" (Wandsnider 1992, 2008:62). The persistent place framework has shown similar utility for addressing these time averaging issues in the Australian arid zone, and these studies have recognized the "the role of multiple behavioural events in the accumulation of the archaeological record" and importance of "understanding the organizational forces that lead to material organization at a place through time" as valuable contributors to landscape research (Davies and Holdaway 2018:126; Holdaway et al. 2008; Shiner 2009:26).

The formation of persistent places is dependent upon three criteria. First, persistent places may be the result of "unique qualities" which facilitate "certain activities, behaviors, or practices" (Schlanger 1992:97). This criterion is largely analogous to optimal environmental conditions, which served to encourage and structure the reuse of the site. For example, the presence of a lithic raw material outcrop or other valued subsistence resource could serve to incentivize the repeated reuse of that place through time. Schlanger's (1992:97) second criterion for persistent place formation is the presence of existing cultural facilities which allow hunter-gatherers to reoccupy a place at reduced cost and "structur[e] the activities associated with those various occupations." Wandsnider (1992) proposed a similar concept in her analysis of the reoccupation of existing features, and conditions controlling reuse of extant cultural facilities. Other similar studies include Smith and McNees' (1999, 2011) work with reuse of pithouses in southwest Wyoming and Morgan et al.'s (2018) experimental investigation of the cost incentives of reusing extant features. Another such example of this criteria of persistent place formation is the reuse of features at the Yarmony Pithouse site, where existing housepits structured the later occupation of the site even though the features were not reused explicitly for their original purpose (Bender 2015). Schlanger's (1992) final persistent place criteria describes the visible traces of artifactual remains from past use as incentivizing the repeated use of landscapes. Under this criteria for persistent reuse of a place, existing artifact accumulations act as a "structuring component of the cultural landscape" which are themselves an "exploitable resource" (Schlanger 1992:97). This criterion is similar to the concept of site furniture, as well as the anticipatory provisioning of items for later use at a site (Binford 1978, 1979; Pelton 2013, 2017; Stiger 2001). Closely related to these behaviors is the practice of caching of tools and raw materials, a land use strategy which represents an inherent intent to reoccupy a given place (Binford 1979; LaBelle 2015b; Landt and Prouty 2017). Under this persistent place formation criterion, ground surface visibility of these material traces is also an important consideration which must be evaluated in the context of the recycling of materials from previous uses of a site (Camilli and Ebert 1992).

Studies of reoccupation, based in this persistent place concept and similar frameworks, have contributed significantly to understandings of high elevation archaeology in northern Colorado. Andrews et al. (2008) and LaBelle and Holen (2008) analyze Folsom site structure to consider the role of reoccupation in Paleoindian landscape use in the Great Plains and Rocky Mountains. LaBelle's (2005:226, 2010) analysis of foraging variability across the Great Plains and Rocky Mountains likewise recognizes the importance of “persistent use of place” to explore why foragers were drawn to the same locales despite functional and environmental changes through time. Bender’s (2015:317) analysis of forager settlement systems in South Park employed the persistent place concept to consider the “explanatory potential of persistently re-occupied places to understand hunter–gatherer land-use decisions.” In her analysis, Bender (2015) points to alpine game drives as an example of high elevation persistent places in the Southern Rocky Mountains. Elsewhere in the literature, game drives are recognized as “accumulated landscapes” which reflect patterns of significant episodic reuse over long periods (Benedict 1992; LaBelle and Pelton 2013:48). As an example of Schlanger’s (1992) second criterion for persistent place formation and Wandsnider’s (1992) discussion of reuse of extant ‘facilities’, these alpine game drives are perfect representations of cultural facilities which are reoccupied and reused at reduced cost. Though occasionally repurposed or modified to fit a specific circumstance, alpine game drive systems are enduring features which structure the reuse of alpine landscapes in the Colorado Front Range. In his approach to reconstructing the occupation history of these features, Meyer (2019a:3) described the “complex nature of occupation, reoccupation, and the persistent use of place” represented by game drives. By applying palimpsest theory to unravel the nature of multiple reoccupation episodes, Meyer (2019a) was able to better understand the nature and character of the reuse and modification of game drive features.

Closely related to the core site formation processes of persistent place theory, the palimpsest concept is a critical tool for understanding the nature and dynamics of reuse of a place through time. Binford (1981:197) first applied the term to archaeology, asserting that the “archaeological record represents a massive palimpsest of derivatives from many separate episodes." Subsequent studies have identified the palimpsest concept as a useful framework for approaching complex questions surrounding the long-term use of sites (Bailey 2007; Davies et al. 2016; Holdaway et al. 2008; Sullivan 2008; Zvelebil et al. 1992). Similarly, rather than focusing on isolating single components from these accumulated deposits, archaeologists increasingly "view any perceived loss of chronological resolution as an opportunity to explore processes operating over spatiotemporal scales" to inform understanding of the long-term use of a locale (Davies et al. 2016:451). In exploring these processes, Bailey (2007) offers a useful framework for classifying and interpreting these palimpsest deposits. Bailey (2007) distinguishes between five types of palimpsest deposits, of which four are most applicable to this study. A 'true palimpsest' refers to a deposit where preceding material traces have been completely erased from the record (Bailey 2007). True palimpsests can occur from cleaning events, or new constructions which eradicate existing deposits (Sullivan 2008). A 'temporal palimpsest', by contrast, is a deposit comprised of non-contemporaneous materials which entered the record simultaneously. These palimpsests are often created through the discovery, use or curation, and subsequent discard of an older artifact alongside younger materials in a single deposit. The Folsom point identified by Benedict (2000:163) at the Fourth of July Mine site (5BL153), which is believed to have been discovered elsewhere and transported to the site by later groups before being deposited alongside these later materials, is a fitting example of a temporal palimpsest. The final two types of palimpsests, 'cumulative palimpsests' and 'spatial palimpsests' are most widely applicable to hunter-gatherer contexts. A cumulative palimpsest refers to "successive periods of deposition" which result in a concentrated deposit of overlain and intermixed materials (Bailey 2007:204). A spatial palimpsest, by contrast, occurs when multiple deposition episodes are spatially segregated but structured around a common cultural or landscape feature

(Bailey 2007). While the material traces of overlying occupations centered on a hilltop represent a cumulative palimpsest deposit, for example, a concentration of spatially discrete non-contemporaneous artifact concentrations structured around a spring would reflect a spatial palimpsest pattern.

Persistent place and palimpsest theories are critical to any analysis of reuse of landscapes. With these concepts defined, it is then necessary to consider the substantial body of literature surrounding the study of occupation span and duration (Meeker 2017; Schiffer 1975; Schlanger 1990; Surovell 2009; Varien and Mills 1997). Many of these methods have likewise originated in the American Southwest, such as discard equation and accumulation theory studies, and are largely oriented around questions surrounding population dynamics and occupation intensity (Schlanger 1990; Varien and Mills 1997). While most of these studies are not explicitly concerned with reoccupation, their methodological emphasis on the study of occupation intensity is also well suited for analysis of reoccupation intensity. There have been a number of attempts to apply similar methods towards recognition of reoccupation in hunter-gatherer settlement systems, such as by Surovell (2009:99) and his application of a “occupation span index” to distinguish between single component and reoccupied sites, however these studies have generally required neatly controlled, expansive, and specially curated datasets (Gallivan 2002). Particularly when dealing with palimpsest deposits, and the “reoccupation problem” as described by Surovell (2009:99), isolating the data necessary to perform these analyses can be challenging and impractical when working with legacy collections. Fortunately, when working in the high elevations of the Southern Rocky Mountains, the punctuated and episodic nature of occupation attributable to the inhospitable winter conditions in these areas generates an archaeological record which is well suited for analysis of reoccupation with these methods.

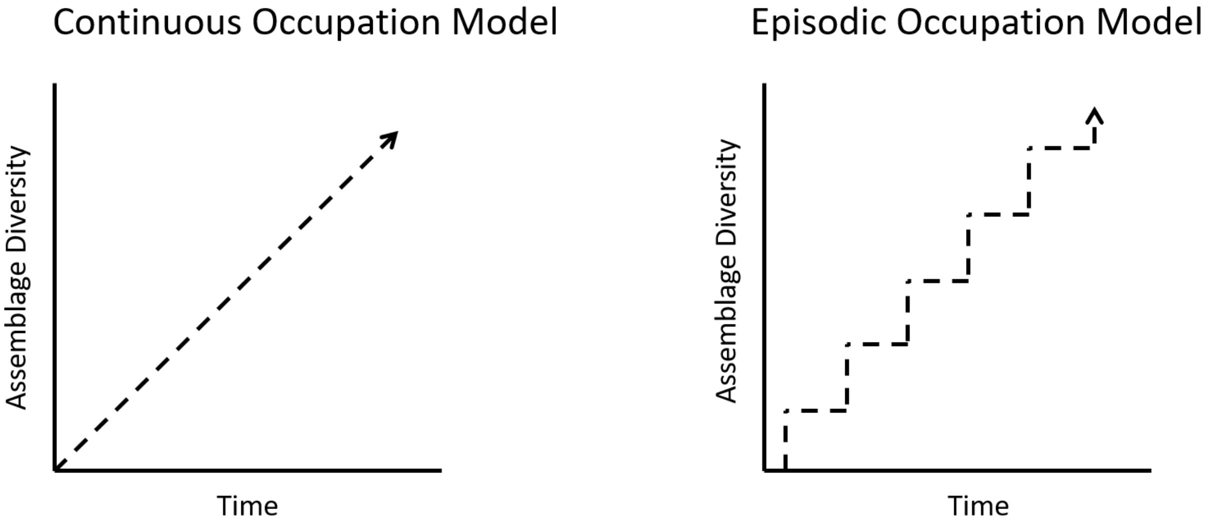


Figure 19. Conceptual models for the relationship between assemblage diversity and occupation span. At left, an idealized representation of the positively correlated relationship between assemblage diversity and occupation span for a continuously occupied site (Schiffer 1975, 1987; Reproduced with modification from Perlmutter 2015: Figure 3.2). At right, a modified model reflecting the idealized relationship between assemblage diversity and an episodic sequence of reoccupation, such as characterizes the seasonal use of high elevation environments.

Though discard equations and accumulations simulations are difficult to implement with a complex palimpsest assemblage, broader concepts derived from these studies are useful for generating expectations for assemblage composition. Schiffer's (1975, 1987) Clarke Effect is one such concept with substantial utility towards the analysis of reoccupation in hunter-gatherer assemblages. Based on analysis of discard rates in simulated assemblages, Schiffer (1975, 1987:55) recognized a "statistical tendency for the variety of discarded artifacts to increase directly with a settlement's occupation span." Subsequent studies appear to validate this observation, recognizing that high intensity occupations will generate more assemblage diversity than ephemeral occupations (Pyszcyk 1984; Schlanger 1990; Surovell 2009). Though the Clarke Effect has significant potential to contribute to analysis of reoccupation, there are a number of problematic aspects which must be resolved prior to application to mountain contexts. First, Schiffer's (1975, 1987) conception of the Clarke Effect assumed a permanent settlement with continuous occupation, which is not consistent with the highly mobile nature of high elevation occupations. Second, though confirming the Clarke Effect, Schlanger (1990) also observed the tendency for short-term occupations to reflect high variability in artifact frequencies, with long-term occupations exhibiting more constant frequencies. Clarification of these interpretive challenges will allow for improved analysis of reoccupation in high elevation contexts.

Though it was conceived with the assumption of a permanent occupation, the overarching patterns described by the Clarke Effect should also be reflected in the episodic reoccupation of sites (Figure 19). If we consider the deposition of long use-life tools as a probabilistic process, with a greater occupation span there is a concomitant increased likelihood for the deposition of artifacts representing a diverse range of activities (Surovell 2009). In representations of the Clarke Effect for permanent or year-round settlements, this pattern is reflected by a positively correlated relationship between occupation span and the range of activities which occur at the site (Perlmutter 2015; Figure 19). In a context where occupation is episodic, such as the high elevations of the Medicine Bow Mountains, I argue these trends would not vary significantly from this baseline. For example, Binford (1982:21) describes how "shifts in […] utility" across multiple occupations of a single site can result in a record reflecting multiple divergent site functions. Similarly, as a place is reused through time, there is an increased probability of multiple distinct activities occurring at the site (Binford 1980; Dooley 2008). Collectively, these concepts suggest that the deposition of a diverse range of artifact types is not inherently less probable for a episodic occupation pattern than for a continuous occupation pattern. We might visualize this as a stair-step pattern, as shown in Figure 19, where with each reoccupation there is a heightened probability of a different activity taking place at the site, and a concomitant increase in the likelihood of a diverse range of tool types being deposited into the record. Similarly, though Schlanger's (1990) observation of variability in artifact type frequencies for short-term occupations could cause interpretive challenges, the long-term reuse of a site should serve to "stabilize" artifact type ratios in the same way which a long-duration continuous occupation would (Surovell 2009:63). With these understandings, the Clarke Effect represents a powerful theoretical framework for investigation of reoccupation in mountain contexts.

Expectations for Reoccupation at High Elevations in the Medicine Bow Mountains

With this theoretical basis in the analysis of persistent reoccupation, it is necessary to apply these bodies of literature to derive expectations for how these patterns may be manifested in the archaeological record of the Medicine Bow Mountains. Based on the persistent place, palimpsest, and reoccupation studies described above, we can determine that evidence of reoccupation should be most recognizable at three scales of inquiry. First, reoccupation intensity should be reflected in the assemblage composition of reoccupied sites. Second, if reoccupation of high elevations is contingent on the "unique qualities" of a place, reuse of facilities, or structured by existing material traces, there should be recognizable patterns in the distribution of sites over landscapes (Schlanger 1992:97; Wandsnider 1992). Third, the site structure of reoccupied sites should represent a palimpsest deposition pattern and exhibit spatial evidence of multiple occupations. Analysis of these three scales of inquiry should therefore generate an improved picture of the nature and extent of reoccupation and reuse of high elevation landscapes in the Medicine Bow Mountains.

Assemblage Composition of Reoccupied Sites

The first scale of inquiry applied in this study is analysis of the role of reoccupation in assemblage composition. As a time-averaged representation of the cumulative range of activities which occurred at sites, site assemblages from extant collections offer significant potential for analysis of reoccupation. In Shiner's (2009:26) study of persistent places, for example, he recognized that the "composition of assemblages […] reflect the long-term repeated use of locations." Reckin and Todd (2020) likewise evaluated variation in occupation duration and intensity at high elevations by integrating landscape-scale and assemblage-scale methodological approaches. Based on these and similar studies, we can derive a number of expectations for how preferential reuse of place may be represented in the assemblage composition of sites from the Rawah Wilderness.

Colorado State University's fieldwork in the Rawah Wilderness, from 1971 to 1996, produced a substantial representative sample of the surface assemblage composition of sites in the study area. Morris et al.'s (1994) 100% observed surface collection strategy for these sites was critical in generating this expansive dataset, and these data represent a complete snapshot of each site's surface assemblage. Similarly, with the continued exposure of materials on the site surface from erosion and bioturbation, sites were revisited on an intermittent basis to enlarge assemblage samples (Morris and Metcalf 1993; Morris et al. 1994; Morris 2010). With this substantial dataset, and the standardized methods utilized by Morris and Metcalf (1993), it is possible to identify sites with the highest evidence of reuse through a comparative analysis. From Schiffer's (1975, 1987) Clarke Effect, for example, we can anticipate that reoccupied sites will reflect a higher tool diversity than ephemeral sites. A paucity of lithic raw materials in the study area should likewise result in a higher lithic raw material diversity at reoccupied sites, caused by the transport of non-local materials into the area across multiple occupation episodes (Bender 2015; Kvamme 1998). Similarly, given a similar rate of discard, sites with repeated reuse should accumulate larger quantities of artifacts than ephemeral sites. As long-use life tools, projectile point abundance should also reflect this trend (Burnett 2005; LaBelle 2010; Schlanger 1992).

Collectively, it is reasonable that reoccupied sites in the Medicine Bow Mountains could be distinguished from ephemeral sites by a number of distinct assemblage composition characteristics. First, reoccupied assemblages should reflect a wider range of site functions and activities than ephemeral sites. Even in time-averaged assemblages, diverse site functions and activities should be measurable through analysis of artifact diversity and typologies. Second, reoccupied site assemblages should exhibit evidence of occupation by discrete non-contemporaneous groups with diverse mobility and settlement systems, a pattern represented by concomitant diversity in the lithic raw materials carried into the study area through time. Over long temporal scales, variable systems of high elevation land use and divergent levels of landscape use intensity should also be reflected by diverse assemblages at reused sites. These patterns can be measured through broader variability in assemblage characteristics, as well as lithic raw material diversity and projectile point abundance.

Distribution of Reoccupied Sites over Landscapes

The second scale of inquiry, addressed by this study, concerns the variability of reoccupation intensity over mountain landscapes. The data sample collected by Colorado State University's previous investigations in the Rawah Wilderness has substantial potential for clarifying the spatial character of reoccupation and long-term patterns in the indigenous utilization of alpine and subalpine environments. Similarly, under Schlanger's (1992) criteria for persistent place formation, analysis of the distribution of sites and variable reoccupation intensity over broader landscapes is critical for evaluation of broader trends in landscape use. Often, though not in all cases, reuse of sites is conditioned by the character of the surrounding landscape. Surovell (2009:109), for example, connected the extent of suitable flat terrain with the probability of eventual overlap and reoccupation. If such conditions are guiding reoccupation in the Medicine Bow Mountains, these trends should be quantifiable. As discussed in Schlanger (1992), the presence of optimal environmental conditions can likewise serve to incentivize the reuse of a place. Accordingly, if the long-term reuse of high elevation landscapes in the Medicine Bow Mountains was structured around access to a specific resource, this should also be recognizable in the landscape distribution of reoccupied sites. Conversely, if there is not a clear connection between persistent place formation and a distinct ecological 'niche', the absence of these patterns strongly suggests that other factors are at play in encouraging the reuse of place. From Schlanger's (1992) perspective, these alternative incentives for reoccupation of a given locale could be tied to existing cultural facilities or settlement of areas with visible traces of past use. For these reasons, a landscape study of persistent places must also consider the ground surface visibility of features and artifacts in the analysis. The paucity of local raw materials within the study area, for example, could incentivize the recycling of discarded materials from previous occupations on the surface of existing of sites (Schlanger 1992; Camilli and Ebert 1992). The discovery of these recyclable materials on the ground surface of a site, discarded during previous occupations, could then encourage reoccupation of the place.

Based on these considerations, we can derive a number of expectations for the likely characteristics of reoccupation over the landscape scale. First, it is reasonable to assume that variability in reoccupation intensity exists across the landscape. Second, if this variability in reoccupation intensity is influenced by the presence of optimal environmental conditions, the distribution of reoccupied sites should reflect a non-random pattern in relation to these landscape characteristics. Third, if no statistically significant trends exists between environmental conditions and reoccupation intensity, other social and cultural factors are likely responsible for the distribution of reoccupation intensity across the landscape. By evaluating archaeological visibility in the distribution of these sites, it is possible to determine if this is attributable to reuse of existing cultural facilities or surface recycling of previously discarded artifacts (Schlanger 1992). Generating and testing hypotheses derived from these expectations will clarify the approaches hunter-gatherers' took to these high elevation landscapes and reveal aspects of their decision-making in the use of these environments.

Spatial Structure of Reoccupied Sites

The final scale of analysis, the distribution of artifacts on the surface of sites, will evaluate the structure of reoccupation and the relationship between space and the reuse of place. The spatial structure of sites is a powerful source of data concerning the repeat use of locales on the landscape, and analysis of artifact distributions has significant interpretive power for understanding the long-term use of a place (Bailey 2007; Burnett 2005; Shiner 2009; Sullivan 1992, 2008). These trends in the site structure of a persistent place should be represented in several ways. First, surface distributions of artifacts should reflect a cumulative and/or spatial palimpsest pattern. In the case of a cumulative palimpsest pattern, we would anticipate a reoccupied site with a surface distribution comprised of a single concentration of artifacts. As a cumulative palimpsest, this concentration will reflect spatially overlapping occupation events which are accumulated on a single place on the landscape. In the case of a spatial palimpsest pattern, we can expect multiple discrete clusters of artifacts structured around a single landscape feature. These clusters may individually be small, representing ephemeral events, however the spatial distribution of artifacts across the larger site will reflect a patchwork of many distinct occupations.

Analysis of the assemblage composition of the clusters which comprise these cumulative or spatial palimpsests can likewise be used to identify evidence of reoccupation from surface artifact distributions. For example, the assemblage composition of a cumulative palimpsest deposit should reflect a high tool diversity, lithic raw material diversity, and assemblage size. As each subsequent occupation overlaps the existing traces of past occupations, the resulting time-averaged surface deposits would reflect elements of the cumulative use of the place through time (Shiner 2009). In a spatial palimpsest by contrast, individual clusters may represent only an ephemeral single occupation. When all non-contemporaneous clusters within a spatial palimpsest are considered together, however, the assemblage composition of the site would reflect these previously identified characteristics of reoccupied site. Though discrete clusters can also exist within a single component site, representing contemporaneous activity areas, in these cases the assemblage composition of individual clusters and the larger site would both reflect limited evidence of reoccupation.

Discussion

The indigenous use of high elevation landscapes in the western United States was highly variable through time and across space. In the case of the Medicine Bow Mountains, with the study area's close spatial proximity to the heavily studied Colorado Front Range, consideration of this variability is especially relevant. With these challenges in mind, it was necessary to turn to broader theoretical frameworks to consider reoccupation and use of place in diverse hunter-gatherer systems. One such framework, the persistent place concept, offers a useful foundation to evaluate trends in reoccupation and reuse of place within high elevation contexts (Bender 2015). Methods and theoretical concepts from site formation studies, such as the Clarke Effect, are likewise well suited to approach these issues (Schiffer 1975, 1987). Based on this body of literature, it is possible to derive expectations for how similar processes of reoccupation and reuse should be reflected at different scales in the archaeological record of the Medicine Bow Mountains. At the level of the time-averaged surface assemblage, for example, we should expect to see a time-averaged and mixed assemblage composition which reflects a high diversity of tool functions and lithic raw materials, alongside other characteristics. On the macro-spatial landscape scale, Schlanger's (1992) first criteria of persistent place formation should be recognizable in the distribution of sites if reoccupation was structured around access to optimal environmental conditions. On the micro-spatial intrasite scale, we can anticipate that reoccupation events should create a palimpsest depositional pattern which reflects the long-term use of the place. Holistically, the theoretical frameworks considered in this chapter demonstrate that definable patterns of indigenous reuse of place exist within the archaeological record of the Medicine Bow Mountains. Approppriately defining expectations for how this persistent use of place is manifested in the Rawah Wilderness, as was the objective of this chapter, is necessary for successfully recognizing and correctly interpreting these patterns.

CHAPTER 4 – RECOGNIZING REOCCUPATION IN SITE ASSEMBLAGES

The objective of this chapter is to define a range for persistent reoccupation based on extant collections and theoretical expectations for reoccupation intensity. The robust curated collections generated from Colorado State University's 25 years of fieldwork in the Rawah Wilderness comprises an invaluable dataset for analysis of reoccupation (Metcalf 1971a; Morris et al. 1994; Morris 2010). These collections, as detailed in Chapter 2, contain a wide variety of lithic raw materials and functional artifact types. Analyses of the frequency of these artifact types and lithic raw materials in site assemblages, alongside a measured theoretical grounding in the archaeological literature, can be used to generate a scale of reoccupation for the WBLR watershed (Schiffer 1975, 1987; Reckin and Todd 2020). We can expect that a range of reoccupation, from ephemeral single component sites to persistently reoccupied multicomponent sites, exists within the archaeological record of the study area (Morris et al. 1994). With this understanding, analysis of artifact assemblages from these sites should reflect evidence of variable reoccupation intensity. Based on a priori expectations for reoccupation described in the previous chapter, there are several assemblage characteristics which are key indicators of persistently reoccupied sites. First, sites with high reuse should be associated with large assemblage sizes and large quantities of tools. Second, reoccupied sites should reflect evidence of high tool functional diversity and lithic raw material diversity (Schiffer 1975, 1987; Schlanger 1990; Reckin and Todd 2020). Third, high reoccupation intensity sites should correlate with large projectile point assemblages comprised of non-contemporaneous typologies (Burnett 2005; LaBelle 2010; Schlanger 1992). This chapter will quantify these expectations and weigh them to generate a multivariate ranking of sites exhibiting the greatest and least evidence of reoccupation. These findings will then be assessed to determine, what is the range of reoccupation intensity in the study area? And, can reoccupation be reliably discriminated from extant collections? The answers to these questions are then applied to frame the analyses in subsequent chapters.

Methodology: Defining a Range of Reoccupation Intensity

In defining a comparative range of reoccupation intensity, it is necessary to select a suitable site sample with consistent sampling methodologies and collection strategies. To ensure the integrity of this study, a total of 30 high elevation archaeological localities from the WBLR watershed were selected for inclusion in the analysis. Two sites were not considered in the analysis, 5LR230 and 5LR17. 5LR230 was omitted due to its involvement in an ongoing longitudinal study on its significant Late Paleoindian component (LaBelle and Meyer 2017; Meyer and LaBelle 2017; Meyer 2019b). 5LR17 was omitted from this analysis because of the incomplete and irregular collection strategy employed during its initial investigation. The site, first documented by Wheat (1947), was recorded based on the descriptions of a local amateur archaeologist and collector named Ralph Culver (Buckner 2019; Wheat 1947). Materials from the site are present in collections at the University of Colorado, however the assemblage is incomplete (See discussion in Chapter 2). In contrast to the incomplete collection from 5LR17, collections by Colorado State University in the WBLR study area from 1971 to 1996 employed a standardized 100% observed sampling strategy and generated a snapshot of the surface context of each site (Buckner 2019; Morris et al. 1994; Morris 2010). 5LR17 was revisited in 2019, with the objective of gathering additional data, however poor ground visibility left the status and condition of the site inconclusive (Buckner 2019). For these reasons, materials from 5LR17 are referenced only in Chapter 2 and not included in the analyses conducted here.

Variable Selection and Multivariate Ranking of Sites

Careful consideration of assemblage characteristics and methodologies for comparing them across sites is a critical step for defining a range of reoccupation intensity from a landscape dataset. In Kvamme (1988a), for example, an integrated analysis of assemblage composition variables was used to classify sites by occupation duration and function. For the present study, five variables with an a priori association to reoccupation intensity and occupation duration were selected for analysis. These variables include assemblage size, tool frequency, tool functional diversity, lithic raw material diversity, and projectile point frequency. These assemblage characteristics were used to independently rank sites, and a mean estimated reoccupation intensity ranking was derived in addition to individual rankings in each variable category. The minimum number of occupations, derived from the number of co-occurring non-contemporaneous diagnostic artifacts, was also quantified but withheld from these rankings as a control (e.g. the presence of Early Archaic and Late Archaic diagnostics suggests a minimum of two non-contemporaneous occupations).

The first variable selected was assemblage size. Assemblage size was defined as the total number of artifacts, including both debitage and tools, in the site collection. The theoretical basis for the inclusion of assemblage size is based in the expectation that with the increased use of a place, artifacts will be accumulated at the site at a higher rate (Schiffer 1987:55; Stiger 2001:64). For each reoccupation of the site, for example, the active use of the place will result in the deposition of additional material into the record. Alone, this variable can be problematic, as the rate of artifact deposition and accumulation can be highly circumstantial and challenging to quantify, and it must therefore be considered alongside other assemblage characteristics. The second variable selected, closely related to assemblage size, is tool frequency. Tool frequency was defined as the total number of formal and informal lithic tools in the site collection, including all functional classes defined in Chapter 2. Though there is a clear logical relationship between tool frequency and assemblage size, inclusion of tool frequency as a variable contributes additional explanatory value which is essential for the analysis. For example, assemblage size is largely dependent on the quantity of debitage artifacts in a site assemblage, which can vary substantially and can be difficult to use as a sole measure of occupation duration or intensity (Meeker 2017). The frequency of lithic tools, by contrast, offers a useful contrast given their longer use life and the less frequent rates of discard and deposition (Schiffer 1987; Schlanger 1990; Surovell 2009). With each subsequent reuse and reoccupation of a site, then, we can anticipate an increased probability of additional tool discard.

Though the frequency of tools is a useful indicator of occupation duration and reoccupation intensity, there can be challenges in distinguishing between multicomponent assemblages and high intensity single occupations. To account for these issues, additional variables are required to isolate sites with high rates of reoccupation. One method to accomplish this is through functional diversity analyses for lithic tools. Diversity analyses consider three principal assemblage characteristics, including, a) richness, or the number of tool classes present, b) evenness, the estimated similarity in abundance of tool classes, and c) heterogeneity, which is the simultaneous measurement of richness and evenness (Bobrowsky and Ball 1989:5). While archaeologists must be cautious in the application of these analyses, as a “single value masks the different properties of richness and evenness”, diversity measures retain significant “potential for resolving functional and processual relationships” (Bobrowsky and Ball 1989:7; Jones and Leonard 1989:3). These measures are likewise often used as measures to define site function, rather than site reuse or occupation intensity (Andrefsky 1998; Chatters 1987). With this study’s emphasis on broader long-term patterns of landscape use and reuse, the specific site function of individual occupations is difficult to isolate in the record and was less critical than clarifying the accumulated use of a site through time (Dooley 2004). Other applications of diversity, for example, have significant utility for evaluating artifact accumulation and reoccupation intensity. As described in Chapter 3, for example, diversity plays prominently into the Clarke Effect and the increase in tool "variety" alongside occupation span (Schiffer 1987:54). Particularly for analysis of high elevation landscapes, where occupations are inherently seasonal rather than permanent, diversity analyses have significant utility for evaluating trends in long-term episodic reuse (Reckin and Todd 2020). While numerous diversity indices exist in archaeology, Shannon's H is among the most frequently applied (Kaufman 1998; Rindos 1989). Shannon's H, also variously described as the Shannon-Weiner or Shannon-Weaver index, is a probabilistic measure which estimates the heterogeneity of a given tool assemblage (Reckin and Todd 2020). Originally defined by Shannon and Weaver (1949) in the context of information theory, the index is calculated using the following formula:

$$Shannon's\ H = -\sum_{i=1}^{s} (Pi \ln Pi)$$

The Shannon H diversity value is derived from the number of tool class categories (s), and relative percentage or proportion of a given tool classes' occurrence (*Pi*) (Bobrowsky and Ball 1989; Reckin and Todd 2020). Though the measure has been criticized for its treatment of sample size and other conditions, it remains a useful method for generating hypotheses and drawing comparisons between assemblages (Conkey 1989; Meltzer et al. 1992; Sullivan and Tolonen 1998; Rindos 1989). These sample size issues, for example, can be mitigated when Shannon's H is calculated from carefully defined tool classes (Reckin and Todd 2020:9). In the case of this analysis, where tool classes were generally ‘lumped’ rather than ‘split’, the Shannon’s H method is an appropriate comparative measure of diversity which can be used to generate useful hypotheses for further analysis.

In addition to the calculation of tool functional diversity, there is also utility in the analysis of lithic raw material diversity for measuring reoccupation (Kvamme 1998:139). High elevation occupations in the Front Range and Medicine Bow Mountains are associated with larger systems of seasonal movement over landscapes (Benedict 1992). The lithic materials collected during these transhumance systems, and subsequently deposited at sites, were acquired through embedded and direct procurement systems. In an embedded procurement system, suitable toolstone is “obtained incidentally” during the course of daily movements through a landscape (Binford 1979:269). In a direct procurement system, by contrast, dedicated trips are made to known quarry or outcrop sources (Bamforth 2006). In their previous study of the Medicine Bow Mountains, Morris et al. (1994:74) recognized that raw materials were imported into the study area in the form of finished tools, and that raw materials were transported a “considerable distance” from their sources. Similarly, analysis of existing geological maps suggests there is low potential for the occurrence of local raw materials within the study area (Workman et al. 2018a, 2018b). Given the paucity of local raw materials in the WBLR watershed, we can anticipate that bands traveling through the area would transport diverse lithic raw material types into the study area, whether practicing embedded or direct procurement systems. As these lithic raw materials are reflective of the “diversity of places and stone sources visited” and the “level of mobility and foraging range”, we can be certain that different groups accessing the WBLR watershed through time imported a diverse range of raw materials associated with their specific annual round and procurement systems (Binford 1980; Clarkson 2008:305; MacDonald 2008).

The lithic raw material diversity resulting from the repeated use of the study area through time is a powerful tool for estimating the level of reuse for each individual site. In Shiner's (2009) study of time-averaged deposits and persistent places, for example, variability in raw material utilization was analyzed to identify sites with evidence of episodic reuse. The results of his analysis determined that variability in lithic raw materials is "indicative of variability in the intensity of occupation over the long-term" (Shiner 2009:38). Meeker (2017) measured ratios of local to non-local raw materials to understand occupation intensity and duration at stone circle sites in the foothills ecotone to the east of the study area. In her analysis, Meeker (2017:44) recognized that "multiple occupations should contain more [raw material] heterogeneity" due to the "different frequencies and types of non-local materials" imported to a given site. Burnett (2005) performed a similar analysis of toolstone variability in surface lithic scatters at high elevations, applying a comparison of lithic raw material diversity to assess occupation intensity. Reckin and Todd's (2020) recent analysis offers the most comprehensive discussion of the relationship between lithic raw material diversity and occupation intensity through time. In their analysis, Reckin and Todd (2020) apply the local-to-non-local proportion model to interpret the intensity of high elevation landscape use through time. While Andrefsky (1998) and Surovell (2009) likewise recognize that raw material assemblages associated with longer duration occupations are likely to become more homogenous as the reliance on local raw materials increases, these models do not account for occupations where substantive local materials are not available. In these cases, where sites without local materials were occupied only during the summer season, we can expect that assemblage raw material composition will become more heterogenous with each subsequent reuse. Given this basis for lithic raw material diversity as an indicator of reoccupation intensity, the Shannon's H diversity for lithic raw materials was calculated using the same methodology employed for tool functional types. To minimize bias from subjective macroscopic visual identification of material types, diversity was calculated from broad raw material classes, such as CCS, quartzite, quartz, and obsidian (see Chapter 2).

The final variable used for ranking assemblages was projectile point frequency. Projectile points, even apart from their diagnostic potential, are a useful measure of the occupation and reoccupation intensity of high elevation localities (Burnett 2005:iv). In her original analysis of persistent places, Schlanger (1992:109) found that projectile points occurred in higher frequencies in surface contexts associated with multicomponent sites. Schlanger (1992) attributed this observation to the long-term use of these multicomponent sites for hunting activities. This interpretation generally aligns with theoretical expectations surrounding tool use-lives and rates of deposition. For example, particularly in a raw material poor area, we may expect that damaged projectile points would be conserved and recycled rather than loosely discarded (Andrefsky 2008; Clarkson 2008). LaBelle (2005, 2010) likewise used projectile point frequency to understand landscape use and reoccupation. To quantify this variable, all artifacts classified as projectile points in Chapter 2 were summed by site. All projectile points, including incomplete or untyped specimens, were included in the count for each site.

Once all variables for quantifying reoccupation intensity were defined and calculated, it was necessary to rank order sites to create a gradient of reuse. Rather than employ a single value or statistic, in which certain variables could eclipse others, an independent multivariate ranking system was required. Each individual variable was ranked using a percentile ranking function in Microsoft Excel. Using this function, each site was assigned a percentage value expressing its relative rank for every variable, which can calculated in relation to the remaining sites in the sample. These individual variable rankings were then averaged to generate a holistic ranking which represented the overall estimated reoccupation intensity of each site. This process allowed for the independent ranking of each variable, and for careful examination of the data and relative influence of each variable, alongside a holistic rank for the larger analysis of the dataset.

Ordinal Classification of Reoccupation Intensity

Once each site was ranked by the assemblage composition variables, it became necessary to interpret and classify the results. For the purposes of this study, an ordinal classification system was adopted to frame the estimated reoccupation intensity of each site. Based on a priori expectations for reuse, discussed in this chapter and Chapter 3, higher ranking sites exhibit the most substantial evidence for persistent reuse through time. In contrast, sites with a lower mean percentile rank are anticipated to reflect significantly lower levels of reuse. To capture this variation in estimated reoccupation intensity, and categorize each locality for greater ease of analysis, each site was assigned to an ordinal scale. This scale was designed to represent three categories of reuse and reoccupation intensity, sites with evidence of high reuse, moderate reuse, and low reuse. Dooley (2004, 2008) employed a similar ordinal classification of sites by reoccupation intensity. Classification of sites into these categories was performed using the mean percentile rank assigned to each site, derived from the individual rankings per each variable. To facilitate classification, each category was defined by dividing the mean percentile site rankings into thirds. Each site in the top 33% was classified as exhibiting high evidence of reuse, the middle 33% were assigned as moderate reuse sites, and the bottom 33% was defined as those sites with low evidence of reuse. Though this method of classification is arbitrary, the theoretical basis for the analyses support consolidation of these sites into these coarse-grained classes. A finer classification method would be problematic, given the data quality and chronometric limitations of this study, and broader categories are most appropriate for this range.

Results: Assemblage Composition Variability and Evidence of Reuse

The results of the multivariate ranking analysis identified nine sites with evidence of high reuse, twelve sites with moderate evidence of reuse, and nine sites with low evidence of reuse (Table 5). Sites with known multiple occupations, as demonstrated by the presence of non-contemporaneous tool typologies, were all correctly classified into the high evidence for reuse classification category. 5LR229, an example of a known multicomponent site with an unusually small assemblage size (n = 21) was likewise classified correctly due to its high tool frequency, tool diversity (H), and lithic raw material diversity (H). Similarly, 5LR132 is associated with an assemblage size (n = 114) which is greater than 87% of the sites in sample, but with no tools and homogenous raw materials. Despite this large assemblage size, 5LR132 likely represents a high-intensity but ephemeral flaking event, and the site was correctly classified as exhibiting low evidence for reuse. These findings further reinforce the integrity of the classification and ranking methodology. In the case of both 5LR229 and 5LR132, the individual ranking for each variable offers useful analytical value while the holistic ranking situates each site within its larger archaeological context. Similarly, while the ordinal classification of sites into high reuse, moderate reuse, and low reuse categories was arbitrary, the results conform to pre-defined expectations. Similarly, the minimum number of occupations variable (withheld as a control) suggests that all known multicomponent sites were classified correctly.

Table 5. Site assemblages ranked by their relative estimated reoccupation intensity. Each site was assigned an individual rank per each variable, as well as a mean percentile ranking which was used to classify each site into ordinal categories of high reuse, moderate reuse, and low reuse sites. The minimum number of occupations, defined by number of non-contemporaneous projectile point typologies, was used as a control for the analysis. All three sites with non-contemporaneous projectile point typologies were classified within the high reuse category.

	VARIABLES												
Site (5LR)	**Total Assemblage Size**	**% Rank**	**Total Tools**	**% Rank**	**Tool Diversity (H)**	**% Rank**	**Lithic Diversity (H)**	**% Rank**	**Projectile Point Frequency**	**% Rank**	**Mean % Rank**	**Minimum Number of Occupations (Point typologies)**	**Evidence of Reuse**
174	160	93%	13	87%	1.264	71%	0.686	100%	7	97%	90%	**3**	High
235/273/274	824	100%	30	100%	0.678	46%	0.587	80%	6	93%	84%	1	High
240	66	70%	13	87%	1.733	96%	0.558	73%	5	90%	83%	**3**	High
153/237	298	97%	21	97%	1.083	64%	0.167	40%	10	100%	80%	1	High
227/228	101	83%	13	87%	1.322	75%	0.323	57%	3	87%	78%	1	High
131	91	80%	5	63%	1.332	82%	0.626	90%	2	67%	76%	1	High
238	148	90%	6	73%	1.011	54%	0.625	87%	2	67%	74%	1	High
233	33	53%	8	80%	1.733	96%	0.562	77%	1	43%	70%	1	High
229	21	37%	8	80%	1.733	96%	0.410	60%	2	67%	68%	**2**	High
134	28	50%	5	63%	1.055	61%	0.490	67%	2	67%	61%	1	Moderate
231	38	57%	4	53%	1.386	89%	0.122	37%	1	43%	56%	1	Moderate
101	16	30%	5	63%	1.332	82%	0.234	47%	1	43%	53%	1	Moderate
158	76	73%	3	33%	1.099	68%	0.206	43%	1	43%	52%	1	Moderate
133	41	60%	6	73%	1.330	79%	0	3%	1	43%	52%	1	Moderate
102	12	27%	3	33%	0.637	32%	0.305	50%	2	67%	42%	1	Moderate
225	24	43%	3	33%	0.637	32%	0.652	93%	0	3%	41%	1	Moderate
234	83	77%	4	53%	1.040	57%	0	3%	0	3%	39%	1	Moderate
232	54	67%	4	53%	0.562	29%	0.092	33%	0	3%	37%	1	Moderate
135	10	20%	2	23%	0.693	50%	0.611	83%	0	3%	36%	1	Moderate
113	26	47%	3	33%	0.637	32%	0.490	63%	0	3%	36%	1	Moderate
236	47	63%	3	33%	0	4%	0.518	70%	0	3%	35%	1	Moderate
132	114	87%	3	33%	0	4%	0.088	30%	0	3%	31%	1	Low
114	10	20%	0	3%	0	4%	0.673	97%	0	3%	25%	1	Low
239	2	13%	2	23%	0	4%	0	3%	2	67%	22%	1	Low
1834	23	40%	1	10%	0	4%	0.305	50%	0	3%	21%	1	Low
226	20	33%	2	23%	0.637	32%	0	3%	0	3%	19%	1	Low
1733	1	3%	1	10%	0	4%	0	3%	1	43%	13%	1	Low
14335	1	3%	1	10%	0	4%	0	3%	1	43%	13%	1	Low
173	3	17%	0	3%	0	4%	0	3%	0	3%	6%	1	Low
224	1	3%	1	10%	0	4%	0	3%	0	3%	5%	1	Low

Assemblage size among the Rawah assemblages was highly variable, with a range exceeding 800 artifacts and a standard deviation of 154 artifacts. The largest site assemblage was from 5LR235/5LR273/5LR274, with 824 artifacts. This site is located at the confluence of the West Branch of the Laramie River and the North Fork of the West Branch of the Laramie River, and is one of the localities consolidated due to the close spatial proximity of the three sites. Variation among assemblage sizes was greatest in sites classified as having high evidence of reuse, and the assemblage sizes of moderate and low reuse sites were much less variable (Figure 20). Tool frequency followed a similar pattern, though with a much more constrained range of 29 tools and a standard deviation of 6.5 tools. The largest tool assemblages were associated with 5LR235/5LR273/5LR274 and 5LR153/5LR237, with a respective tool frequency of 30 and 21. Variation in tool frequency was largely consistent with total assemblage size, unsurprisingly, and a strong correlation exists between the two variables (Pearson's r = 0.8701). The tool frequencies of high reuse sites again exhibited substantial variability, while moderate and low reuse sites were generally closely constrained. While there was substantial overlap between the high, moderate, and low reuse site classes for assemblage size, there was negligible overlap in values for tool frequencies (Figure 20). This level of overlap is largely consistent with expectations, as large assemblages associated with low reuse sites could be attributed to high intensity ephemeral occupation or a dedicated ephemeral activity area. For example, a lithic reduction or tool retouch activity area could easily generate significant amounts of debitage from a single event. The consistent increase in tool frequencies across classes likewise aligns with this interpretation, as the accumulation of tools is less variable and more constant than debitage accumulation (Schiffer 1975, 1987; Schlanger 1990; Surovell 2009).

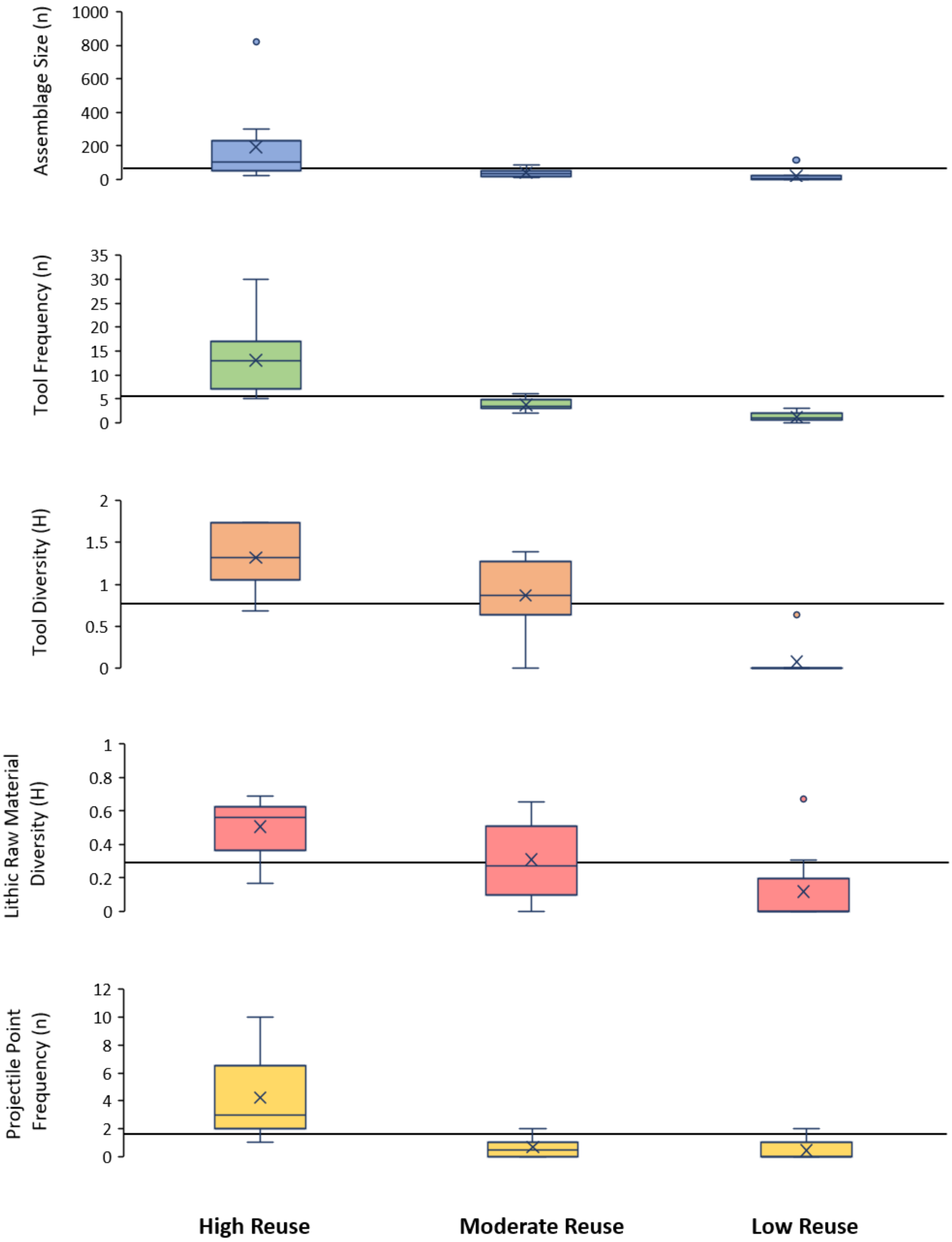


Figure 20. Assemblage composition box-and-whisker plots for sites classified as high, moderate, or low reuse. Solid horizontal lines represent the mean value for the entire site sample (n = 30).

Tool functional diversity and lithic raw material diversity reflect similar patterns as assemblage size and tool frequency. Tool functional diversity is highly variable across the larger study area sample, with a range of 1.73 and a standard deviation of 0.60. The sites with the highest tool functional diversity were 5LR240 (H = 1.73), 5LR233 (H = 1.73), and 5LR229 (H = 1.73). Both 5LR240 and 5LR229 are known to have multiple components based on non-contemporaneous projectile point typologies, and their associated high diversity (greater than 96% of study sites) seems to support expectations derived from the Clarke Effect discussed in Chapter 3 (Schiffer 1975, 1987). By category, sites with evidence of high reuse and moderate reuse reflect similar variability in tool functional diversity (Figure 20). Sites with evidence of low reuse, by contrast, show little variation in tool diversity across their assemblages. This is largely attributable to the small numbers of tools associated with assemblages exhibiting little evidence for reoccupation, as many of these sites meet the management criteria for designation as isolated finds. Similar trends are apparent in analysis of variability in lithic raw material diversity, with a range of 0.69 and a standard deviation of 0.26. Localities exhibiting the highest raw material diversity include sites with evidence of high reuse 5LR174 (H = 0.69) and 5LR225 (H = 0.65), and low reuse 5LR114 (H = 0.67). Both 5LR174 (n = 3) and 5LR225 (n = 1) contain obsidian debitage, and 5LR225 is likewise associated with an obsidian drill (5LR225-23; Figure 12). The presence of obsidian is rare in the Medicine Bow Mountains, accounting for just 0.21% of the artifacts analyzed in this analysis (See discussion in Chapter 2). Likewise, obsidian sourcing studies conducted in study area and in the foothills ecotone to the east, suggest obsidian was imported to northern Colorado from as far away as Idaho, Wyoming, and New Mexico (LaBelle 2009; Pelton et al. 2016:14). The presence of obsidian at these sites, with evidence to suggest their high reoccupation intensity, is aligned with expectations for an increased probability of raw material diversity and occurrence of exotic materials with higher reoccupation intensity (Bender 2015:310; Kvamme 1998). 5LR114 appears somewhat enigmatic by contrast. Designated as exhibiting low evidence of reuse, largely attributable to a complete lack of tools and an assemblage size of just 10 artifacts, the site's assemblage composition does reflect a surprisingly high raw material diversity. It is possible that this discrepancy is a result of the sampling strategy employed or surface discovery bias (e.g. Wandsnider and Camilli 1992, Simmons 1998, etc.), however it is unclear. Given the small assemblage size of this site (n = 10), however, I argue 5LR114 is appropriately categorized as a site with low likelihood for reoccupation. Additional study of lithic raw material sourcing in northern Colorado could clarify the nature of outliers in lithic raw material diversity for the Rawah Wilderness study area.

The final assemblage composition variable, projectile point frequency, was also closely aligned with the trends apparent in previous variables (Figure 20). High reuse sites again reflected more variability in the number of projectile points identified at each site, while moderate reuse and low reuse sites were significantly more constrained. For the Rawah Wilderness site sample (n = 30) as a whole, the range of projectile point frequency was 10 points with a standard deviation of 2.40. Sites with the highest quantities of projectile points, such 5LR153/5LR237 (n = 10) and 5LR174 (n = 7), also represent localities with large assemblage sizes and high tool frequencies. By proportion of the total tool assemblage, projectile points also occur more frequently at these sites than other sites identified as reflecting high evidence of reuse. Some interpretation of site function could be made from these trends in tool assemblage composition, however the chronometric restraints of this study limit analysis to long-term patterns in the use of sites rather than evaluation of short-term function (Dooley 2004:107). In the low reuse category, we also see isolated projectile points which comprise the entire assemblage of the site. These artifacts, typically defined as isolated finds for management purposes, are also important for understanding contrasts in the intensity of landscape use (Dunnell 1992; Schlanger 1992:101). In the case of the Rawah Wilderness assemblages, these likely represent missed or dropped points related to hunting activity and a single snapshot in time.

Generally, the results of the analysis for each assemblage composition variable align with expectations. The classification of sites into ordinal categories by their evidence for reuse likewise was consistent with expectations, with minor variations among individual sites. The analysis suggests that assemblage composition of the sites exhibiting the most evidence of reuse is associated with higher variability in assemblage composition. Although these sites do have large assemblage sizes and tool quantities, high tool and lithic raw material diversity, and large numbers of projectile points, there can be a high degree of variance among these assemblage characteristics. In contrast, sites with moderate or low evidence of reuse tend to be associated with more defined and constrained ranges in their assemblage variation (Figure 20).

Discussion: Implications of Assemblage Composition for Analysis of Reoccupation

The assemblage analysis of 2,372 artifacts identified a number of trends which warrant further analysis. The objective of this chapter was to identify a range of reoccupation intensity for the study area based on assemblage composition, and to determine if reoccupation could be reliably discriminated from extant collections. The results of the analysis, as detailed above, suggest that these methods are appropriate for identifying sites with evidence of reuse and reoccupation can be discriminated from extant collections even when typological diagnostic markers are not present. Though this is not a replacement for absolute dating, and deals with coarse-grained chronometric scales, these methods and the establishment of relative scales of reoccupation intensity are useful for understanding spatial and temporal trends. Similarly, the range of reoccupation intensity elucidated by this analysis demonstrates that reuse of place at high elevations in the study area was significantly more variable than previously understood. For example, many fewer sites exhibit typological evidence of reoccupation than anticipated, creating the need for this alternative method for investigating reoccupation intensity. Though Morris et al. (1994) assigned temporal periods to many more of these sites, this study employed a more conservative approach. For example, Morris et al. (1994) used distal and medial portions of fragmented projectile points in their chronology building, as well as non-projectile point forms such as big knives and beaked end scrapers (See discussion in Chapter 2). Though this study limited temporal affiliations to projectile points and preforms with intact hafting elements, the sites identified by Morris et al. (1994:68-69) as having multiple components were largely consistent with the sites identified as having the highest evidence of reuse in this analysis. For example, 90% of the WBLR watershed sites which Morris et al. (1994) identified as having multiple components (n = 10) were classified as exhibiting high evidence of reuse by this study. The remaining multicomponent site identified by Morris et al. (1994) which was not classified in the high reuse category, 5LR102, was categorized as a moderate reuse site by the multivariate ranking system. All of the sites classified as low reuse, were accordingly identified as having only a single temporal affiliation by Morris et al. (1994). This level of consistency between Morris et al.'s (1994) analysis and the current study is a striking endorsement of the methods employed here, as well as the utility of analysis of reoccupation through comparative evaluation of assemblage composition.

Following confirmation that these results are appropriately aligned with previous analyses, we can turn to the interpretation of variability in assemblage composition for sites with evidence of high reoccupation intensity. As discussed above, moderate and low reuse sites appear to have limited variance and consistency in their assemblage composition (Figure 20). In contrast, despite comprising just nine site assemblages, localities with evidence of high reoccupation intensity exhibit significant degrees of variance in their assemblage composition. These contrasts have great interpretive potential for understanding variability in site reuse and settlement across the high elevation landscape of the study area. Namely, it suggests that patterns in assemblage composition are not consistent across all sites with evidence of reoccupation. Additionally, it indicates that a wide variety of occupation intensities and durations, as well as settlement patterns and site functions, are associated with these sites. This variability in assemblage composition is likely attributable to the effects of time-averaging and the "successional use" of these locales through time (Binford 1981:204). As surface collections, assemblages from these sites may represent artifacts deposited over thousands of years and many occupations. With each reoccupation, the function of individual occupations at a given site becomes increasingly masked by the palimpsest accumulation of artifacts through time (Binford 1982; Dooley 2004). Similarly, these reoccupied sites may represent contexts where "shifts in [..] utility" resulted in the divergent functional use of a place through time, or locales where "particular resource[s] that might have drawn groups to the site […] were perhaps no longer there in subsequent periods" (Binford 1982:21; LaBelle 2010:43). Especially in the context of the seasonal use of high elevations, variable transhumance systems could likewise result in reoccupied sites with assemblages which were dependent on the geographic scale of the annual round. For example, Binford (1982:20) observed that "the more seasonally repetitive the movement of residential sites, the greater the chance for repetitive types of occupations at particular logistical sites", and that non-repetitive and large-scale transhumance systems would conversely result in greater “occupational differentiation and […] assemblage heterogeneity” than a more repetitive annual round. Based on these observations, we might speculate that variability in the assemblage composition of reoccupied sites could be tied to differences in landscape use and settlement of the Medicine Bow Mountains through time. Reoccupation of these locales was episodic and, very likely, sporadic. Especially over thousands of years the material remains of a diverse range of activities and settlement patterns are reflected on the surface of these sites (Schiffer 1975, 1987). Over these millennia, groups likely accessed the high elevations of the Rawah Wilderness from different areas of the larger northern Colorado and southern Wyoming region, as part of variable systems of seasonal transhumance along the Southern Rocky Mountains (Benedict 1992). I argue that these divergent patterns of landscape use through time are more likely to be reflected in heavily reoccupied sites, where traces of these diverse activities are overlain, and therefore assemblages of reoccupied sites are more likely to exhibit substantial variability in their assemblage composition. As a site is reoccupied, intermixture of cultural materials from these discrete occupations creates a variable record reflecting a time-averaged snapshot of these diverse activities through time. In the case of the Rawah Wilderness assemblages, variability among the assemblage composition of sites identified as exhibiting high evidence for reuse is another line of evidence which supports their classification as reoccupied sites.

CHAPTER 5 – SPATIOENVIRONMENTAL MODELING OF REOCCUPATION

The objective of this chapter is to identify landscape patterns which may correlate with selective reoccupation of place in the WBLR watershed. While the previous chapter identified sites with the highest evidence of reuse, based on an assemblage composition analysis of extant collections, this chapter compares and contrasts the spatioenvironmental context of sites with high, medium, and low evidence of episodic reuse. Under Schlanger's (1992:97) framework for persistent place formation, the presence of environmentally advantageous conditions ("unique qualities") at a site can be a powerful pull factor which encourages preferential reuse. For example, opportune access to a lithic raw material outcrop, a mountain pass, or a strategic viewshed can incentivize and structure the repeat use of a given place. Binford's (1980:13) recognition of the practice of "mapping on" in forager settlement systems, where hunter-gatherers strategically utilized areas with critical resources, is also consistent with this expectation. If optimal environmental conditions were a leading factor of persistent place formation in the high elevation landscapes of the Medicine Bow Mountains, we can expect to see evidence for spatial patterns in the distribution of heavily reoccupied sites over the landscape. In assessing these patterns, however, it is important to avoid unsubstantiated interpretations which rely on environmental determinism. Instead, it is necessary to recognize that, while the environment imposed limitations or incentives for the use of landscape, hunter-gatherers made agentive choices in the avoidance or settlement of these places (Rademaker and Moore 2019:103). Similarly, when working at this scale, it is critical to recognize that both human and natural forces mutually acted upon each other to influence how these inherently cultural landscapes were used by ancient hunter-gatherers (Sauer 1925). With this understanding, this chapter explores these agentive choices which led hunter-gatherers to selectively reuse certain places over others. Through this approach, it is then possible to evaluate the role of environment in persistent place formation while considering the complex ways in which people approached and perceived these landscapes.

To identify the contribution of optimal environmental conditions to the preferential reoccupation of sites, this chapter applies statistical and probabilistic techniques to determine if certain landscape settings were strategically selected for repeat settlement. If the analysis identifies evidence for an association between reoccupied sites and a specific suite of environmental conditions, we can argue that Schlanger's (1992) first criteria of persistent place formation is a leading factor in reuse of place in the Rawah Wilderness. If such evidence is not apparent, however, it suggests that social or cultural dynamics may be stronger influences guiding reuse of place. Schlanger's (1992) remaining two criteria for preferential reuse of place, the draw of past artifactual traces visible on the landscape and reuse of existing features at reduced cost, likewise have implications for place-making and may explain reoccupation in the absence of a clear environmental pull. The clear absence of a preferentially occupied environmental niche is likewise evidence for unrecognized cultural conditions which could be responsible for persistent place formation and the "intergenerational commitment of a group to a particular landscape" (Scheiber and Zedeño 2015:1). With these expectations, this chapter addresses the following questions. Is there an identifiable landscape or ecological signature for occurrence of persistently reoccupied sites? To what degree do environmental conditions contribute to high degrees of reuse? Are there substantive differences between environmental conditions associated with high, moderate, or low evidence of reoccupation? And, how does reoccupation intensity vary across diverse ecological and environmental conditions? To address these questions, this chapter will apply a Maximum entropy (Maxent) spationvironmental modeling methodology to identify the environmental conditions which exert the most influence on site suitability. By creating a separate maxent model for high, moderate, and low reuse sites, as defined in Chapter 4, we can then compare the results to determine if sites that are more likely to be reused are associated with specific environmental conditions.

Methodology: Comparative Modeling of Reoccupation Intensity

The Maxent methodology originated for the development of species distribution models in ecology, though recent archaeological applications of its "consistently competitive" predictive capabilities have shown it outperforms conventional archaeological modeling methods (Elith et al. 2010:2; Galleti et al. 2013; Healy et al. 2017; Noviello et al. 2018). Conventional archaeological predictive models are broadly organized into two categories, inductive and deductive models, and apply different datasets and expectations to predict suitable site locations (Verhagen and Whitley 2012). Inductive models use statistical correlations between known archaeological sites and environmental conditions to predict site locations, while deductive models rely on a priori "knowledge of ancient human characteristics" to identify suitable areas for site occurrence (Noviello et al. 2018:35). The Maxent modeling method applies an inductive framework of statistical inference to analyze site suitability and the relationships between site occurrence and certain environmental variables. Maxent's algorithm is derived from the principle of maximum entropy which "states the estimate of the subject probability distribution should be based on known constraints as expressed by an expected value, but the distribution also should be as close to uniform as possible to avoid being biased" (Galleti et al. 2013:48; Philips et al. n.d.). The mathematical basis for Maxent is "maximally non-committal with regard to missing information" and stems from information theory and Bayesian statistics (Jaynes 1957:620).

A central characteristic of the Maxent methodology is its ability to make statistical inferences based on ‘presence-only’ data. While conventional spatial modeling methods require both presence and absence data, Maxent’s algorithm is designed to work with presence data alone. For archaeological applications, this presence-only capability is essential given the difficulty of verifying absence data in remote conditions. For example, it is straightforward for archaeologists to verify locations of archaeological sites (presence data), but substantially less practical to fully verify a lack of sites (absence data) given preservation and visibility biases. In the Rawah Wilderness, this is especially challenging given a lack of formal survey coverage. Especially with the legacy dataset available for this study, the Maxent methodology offers a useful opportunity to apply this preexisting presence-data to analyze the landscape distribution of persistently reoccupied sites.

While Maxent’s most common use is as a predictive tool for development of archaeological predictive models, there is growing application of Maxent as a tool for evaluating the spatioenvironmental conditions associated with specific site types or cultural behaviors. In Howey et al. (2016) for example, Maxent is applied to study differences in the construction of monumental architecture in precontact Michigan. By applying spatial distribution datasets for two types of earthwork constructions, the authors ran Maxent models for each type to compare and contrast the cultural processes and environmental conditions associated with the construction of these features (Howey et al. 2016). Benner et al. (2019) and Walker (2019) performed similar comparative analyses using Maxent’s predictive capabilities. In Benner et al.’s (2019) ethnoecological analysis, Maxent was applied to compare the archaeological and contemporary distribution of culturally significant old growth trees in British Columbia. Walker (2019), in a more conventional archaeological analysis, applied Maxent’s spatioenvironmental powers to compare land use strategies and the persistent use of place between the Late Archaic and Middle Woodland periods in the Trent Valley. Though Walker (2019) does not consider ‘persistence’ in the same theoretical context of Schlanger’s (1992) persistent place concept, her study highlights the potential for Maxent to be applied to understand reuse of place over both time and space. Alongside these studies, this analysis likewise employs Maxent for its comparative powers rather than its predictive modeling applications. By developing Maxent models to compare the spatioenvironmental contexts of high, moderate, and low reuse sites, it is possible to capitalize on these capabilities to “develop robust models of past cultural processes” (Howey et al. 2016:7443)

Sample Size and Quality

A critical component of the development of accurate spatioenvironmental models is the selection of an appropriate sample size and environmental dataset. These input data, the presence-data (known sites) and the environmental data layers, are weak points in the modeling process with the highest risk of user-introduced detrimental biases. For example, the training-sample of known sites can be hampered by spatial autocorrelation, where closely associated data points create redundancy in observation data (Lee 2017). Tobler’s first law of geography, for example, holds that “everything is related to everything else, but near things are more related than distant things” (Tobler 1970). For this reason, dispersed input observation data is preferable over clustered data. A benefit of the Maxent program is that it does contain a parameter to remove duplicate presence records (observations occurring in the same grid cell), which significantly mitigates the potential for spatial autocorrelation biases (Phillips et al. n.d.). Similarly, the use of site distributions derived from survey, rather than a true random sample, is acceptable for these models (Kvamme 1988c: 302).

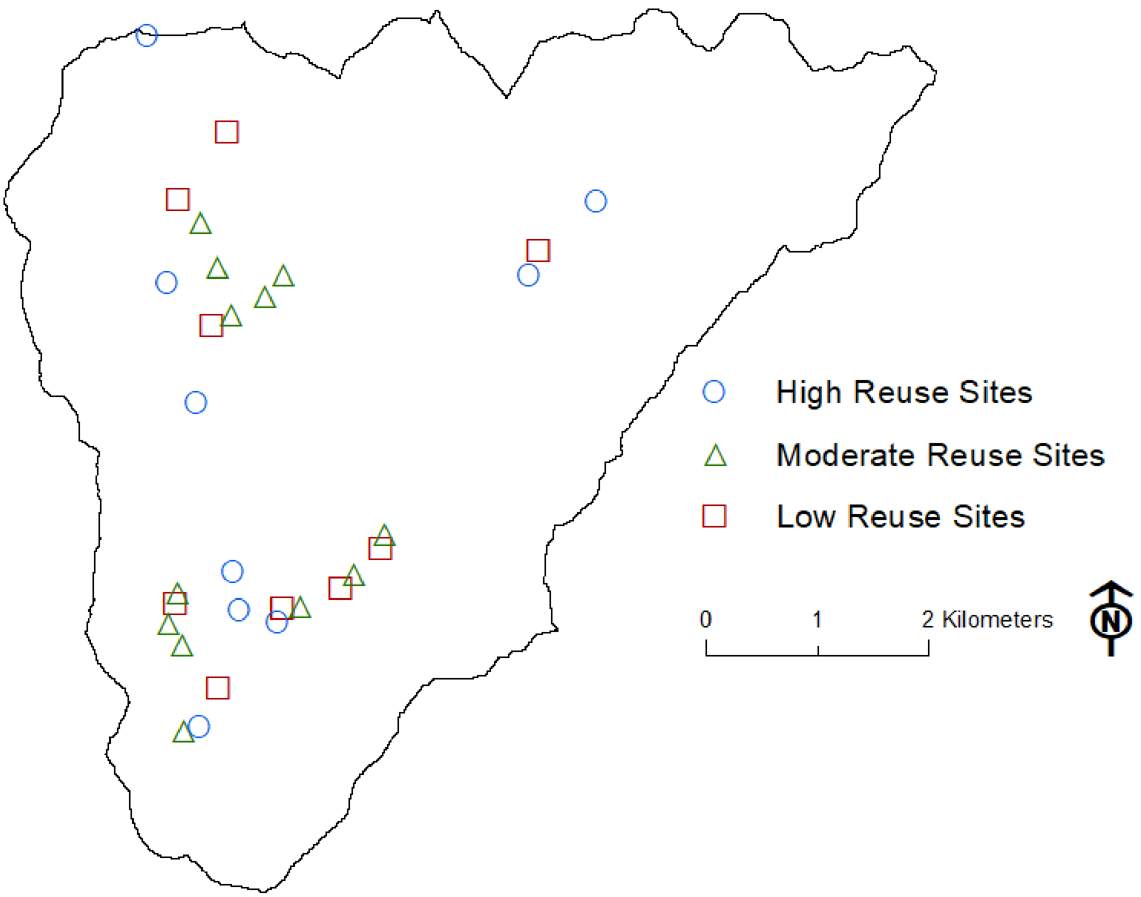


Figure 21. The input observation samples (known sites) used for each model. Spatial autocorrelation can impose some limitations on spatioenvironmental models, however the distribution of each site type is sufficiently dispersed to mitigate any biases caused by autocorrelation. Similarly, the density of each site type per square kilometer exceeds the minimum recommendation of Noviello et al. (2018). Background contextual information was omitted from the figure to protect site locations.

An appropriately sized sample for the input presence-data (known sites) is also a critical component of developing effective models. Though small sample sizes are not necessarily problematic in Maxent, larger samples allow for greater flexibility in model development (Benner et al. 2019:1380; McMichael et al. 2013:3; Proosdij et al. 2015). In the application of their archaeological model, Noviello et al. (2018:34) recommend a minimum density of 0.2 sites per square kilometer for design of an effective Maxent model. Using this standard, the site samples for sites with high evidence of reuse (n = 9), moderate evidence of reuse (n = 12), and low evidence of reuse (n = 9) are appropriately sized for analysis. The total area of the WBLR watershed study area is 36.9 square kilometers and densities for each site type range from 0.24 to 0.32 sites per square kilometer, indicating the available samples are sufficient for analysis with Maxent.

Environmental Variables

Following selection of an adequate sample for heuristic development of the model, it is necessary to isolate environmental predictors which are likely to be associated with suitability of site occurrence. Variable selection is dependent on the a priori expectations of the user, and this stage of the modeling process requires careful consideration of these expectations. For this reason, it is critical to ensure the basis for potential environmental predictors are adequately grounded in best available archaeological evidence. For the purposes of this analysis, a suite of 10 environmental variables was selected to evaluate the suitability for high reuse, moderate reuse, and low reuse sites. These variables were selected from three broad categories which were likely to influence ancient peoples' use of high elevations, water availability, geomorphology and terrain, and ecology and landcover (Table 6). Variables in the water availability category include access to lakes, permanent running water sources (e.g. perennial streams), and ephemeral running water sources (e.g. seasonal streams). Geomorphology and terrain variables include elevation, slope, topographic position, topographic relief. The final category, ecology and land cover, includes proximity to ecotone boundaries, archaeological visibility, and ecological diversity. All environmental variables represent modern conditions and no paleoenvironmental reconstruction was performed for this analysis. In absence of this paleoenvironmental data, as in Howey et al. (2016:7445), contemporary variables were applied to understand "how areas across the landscape would have varied […] relative to each other." Similarly, though sites were evaluated in the context of these contemporary environmental variables, if the distribution of sites in relation to the variables results in the clear identification of nonrandom patterns there is then still utility for understanding the landscape distribution of these sites (Kvamme 1992:23).

Table 6. Environmental variables used to construct the models for high reuse, moderate reuse, and low reuse sites. These variables were selected based on a priori expectations for their likely significance to prehistoric utilization of the WBLR watershed.

Variable	Source	Description
Water Access		
Cost Distance to Lakes	National Hydrography Dataset	Measures the cost (as a function of slope and distance) to access lakes.
Cost Distance to Permanent Water	National Hydrography Dataset	Measures the cost (as a function of slope and distance) to access perennial running water sources.
Cost Distance to Ephemeral Water	National Hydrography Dataset	Measures the cost (as a function of slope and distance) to access ephemeral and seasonal running water sources.
Geomorphology and Terrain		
Elevation	USGS	Measures elevation in meters above sea level.
Slope	Derived from Elevation	Measures the steepness of terrain.
Topographic Position	Derived from Elevation/Slope	Measures placement of sites in high (ridgelines) and low (valley floors) points in relation to surrounding terrain. Derived from elevation variability in 100-meter radius.
Topographic Relief	Derived from Elevation/Slope	Measures the ruggedness and difficulty of movement through terrain (large changes in elevation over short distances). Derived from variability of elevation over a 500-meter radius.
Ecology and Land Cover		
Cost Distance to Ecotone Boundary	Derived from Elevation	Measures the cost (as a function of slope and distance) to access ecotone boundaries.
Archaeological Visibility	Derived from CIR imagery, SWReGAP Land Cover, and Constructed Datasets	Proxy for visibility of sites to (a) prehistoric peoples, and (b) modern archaeological surveyors. Provides estimated visibility of artifactual materials on the ground surface.
Ecological Diversity	Derived from Land Cover	Measures the number of discrete land cover types within a 100-meter radius.

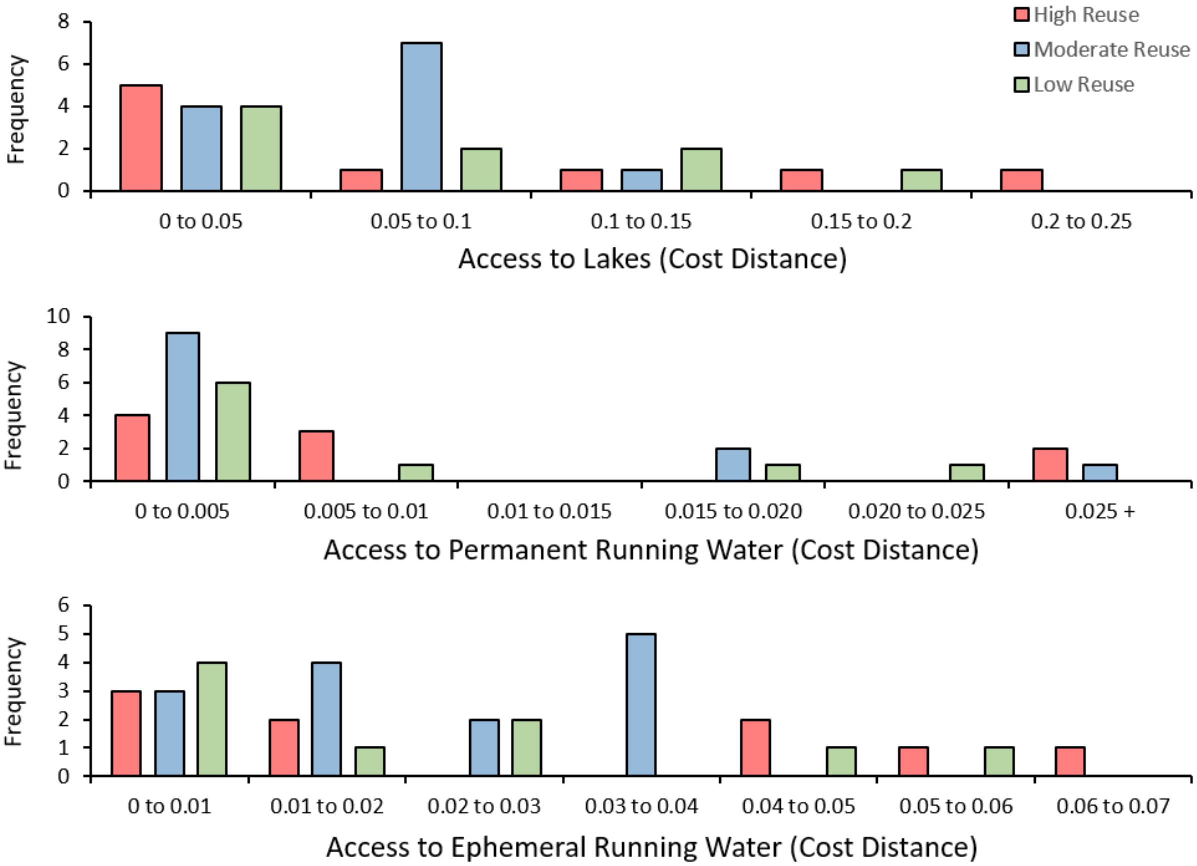


Figure 22. Frequency of site occurrence by cost to access water resources. Low values indicate a minimal cost to access, while high values correspond to high cost. These variables include lakes, permanent running water (such as perennial rivers and streams), and ephemeral running water (such as seasonal snowmelt channels).

For variables which measured proximity and access (such as water access or ecotone boundary), a cost distance raster was created. As a function of slope and distance, this raster measures the relative energy expenditure required to access the given resource. This is critical in mountain contexts, as a resource can be in apparent close proximity but far upslope or downslope (Buckner 2020). By using a cost distance raster to measure ease of access to a given resource, the models can measure proximity more accurately than by using distance alone. To create the cost raster, the mean slope and standard deviation of slope within a 100 meter radius of each cell was calculated using the Focal Statistics tool in ArcGIS. A value of ‘1’ was added to each raster using the Raster Calculator tool, and the natural log was taken for each cell using the Ln tool.

The resulting rasters were then combined in the Raster Calculator to generate the cost surface raster (Heilen et al. 2013).

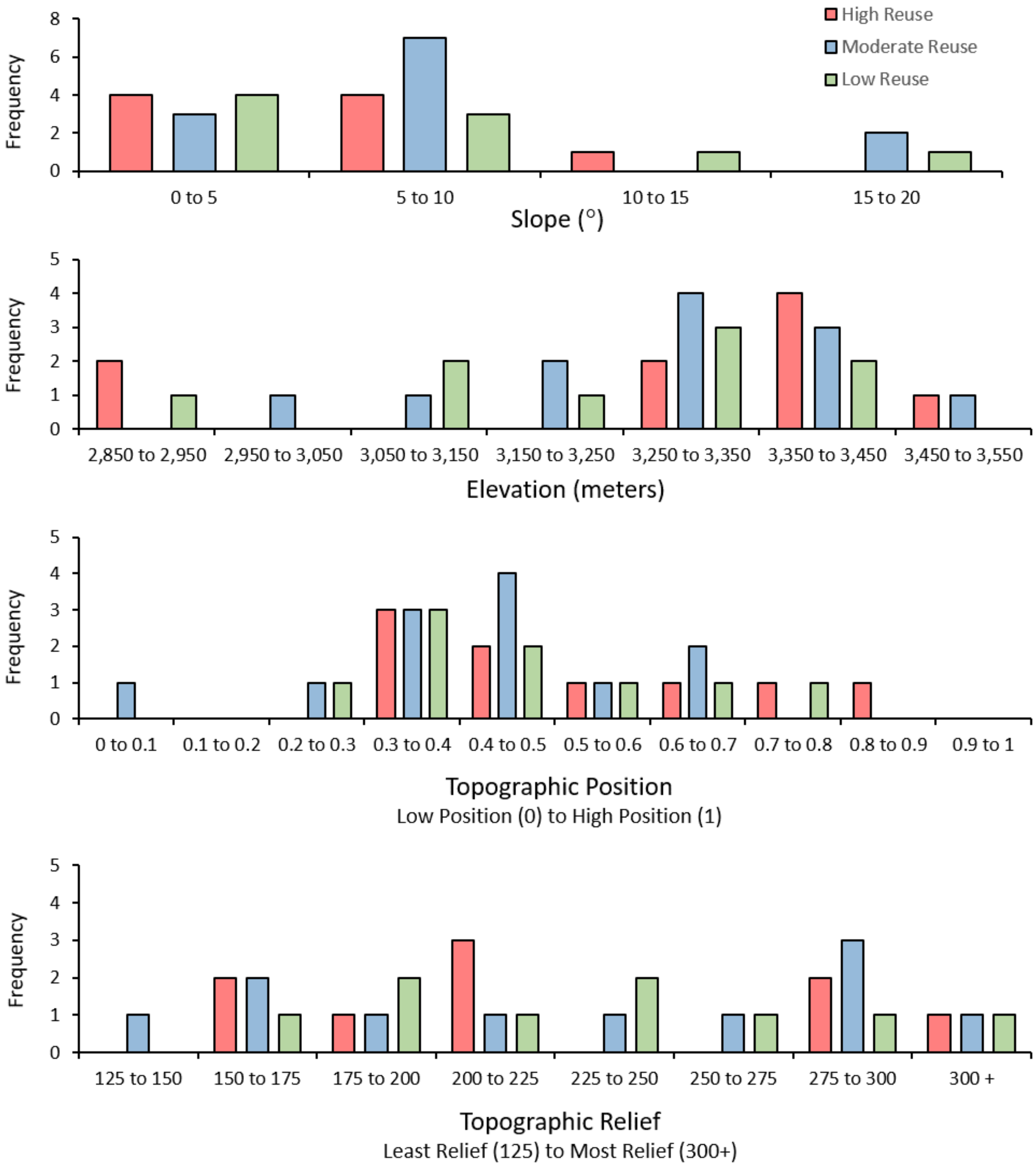


Figure 23. Frequency of site occurrence in different geomorphic and terrain conditions. These variables include elevation, slope, topographic position (high and low vantages), and topographic relief (terrain ruggedness).

The water resources category is comprised of variables which measure cost to access lakes, permanent running water, and ephemeral running water. Access to water is a well-established variable in archaeological predictive modeling, and an important consideration in modeling differences between sites with variable reoccupation intensity (Kvamme 1988b). Morris and Metcalf (1993), accordingly, reported concentrations of sites nearby to water resources. Lakes are generally associated with the high elevation cirque basins of the WBLR watershed, while permanent and ephemeral running water sources are more variable throughout the study area. A number of Rawah sites are associated with lakefront settings in these high elevation contexts, and it is important to consider if these landscape features are associated with reoccupation (Morris et al. 1994). Additionally, given that primary drainages are also expedient travel routes through rough mountain terrain, proximity to permanent running water and drainages may also reflect travel corridors through the study area (Buckner 2020). Similarly, sites associated with ephemeral running water sources could reflect how indigenous peoples utilized areas of the landscape where permanent sources were not available. Each raster for these variables was created using shapefiles acquired from the National Hydrography Dataset and the Cost Distance tool in ArcGIS

The geomorphology and terrain category includes the slope, elevation, topographic position, and topographic relief variables. Elevation and slope were derived from a digital elevation model (DEM) available from the United States Geological Survey (USGS). These are common variables in geospatial modeling in archaeology, and are particularly relevant to mountain contexts. Steep slopes, for example, inhibit both travel and settlement and are a useful predictor of sites occurrence. The topographic position and topographic relief variables were more complex and required significant data preparation. The topographic position raster measures if settlement patterns are associated with a preference for either high (e.g. ridgelines) or low (e.g. valley floors) vantages (Holton 2013). The raster measures the difference in elevation in a 100 meter neighborhood to estimate the position of a cell in relation to the surrounding topography. Following the methodology of Holton (2013:47), the raster was created using the Focal Statistics and Raster Calculator tools and the following equation:

$$Topographic\ Position\ = \frac{(DEM - \ Minimum\ Elevation)}{(Maximum\ Elevation - \ Mininimum\ Elevation)}$$

The topographic relief raster considers similar aspects of variability in terrain and its implications for settlement and movement. Relief acts as a proxy for the ruggedness of local terrain, which can expediate or limit settlement and movement through a given area (Heilen et al. 2013; Kvamme 1988b). To calculate the relief raster, the range of elevation within 500 meters of each cell was calculated using the focal statistics tool. Relief is high in areas where there was significant variability in elevation, and low in areas with little variation in elevation.

The final environmental category contains variables related to ecology and land cover. These variables include ecological diversity, proximity to ecotone boundaries, and archaeological visibility. Ecological diversity acts as a proxy for the variance in land cover and vegetation in close proximity to site, with the expectation that hunter-gatherers will strategically map on to areas with access to a range of resources (Binford 1980). The ecological diversity raster was created using a land cover dataset from the Southwest Regional Gap Analysis Project (SWReGAP). Using the Focal Statistics tool in ArcGIS, the raster was created using the number of discrete land cover types which occurred with 100 meters of each cell. The proximity to ecotone boundaries raster was created with a similar intent. Evidence from the Medicine Bow Mountains and Colorado Front Range suggests that hunter-gatherers strategically positioned themselves nearby to the timberline ecotone for protection from wind and elements, as well as expedient access to the subsistence resources unique to both the subalpine and alpine ecozones (Benedict 1981, 1985, 1992, 2000; Morris and Metcalf 1993; Morris et al. 1994). With the diverse resources available from ecotone boundaries, and close access to resources from multiple ecozones, proximity to these transitional areas could encourage reoccupation. The cost distance to ecotone boundary variable acts as a proxy to measure these settlement and resource procurement strategies practiced by hunter-gatherers in high elevations.

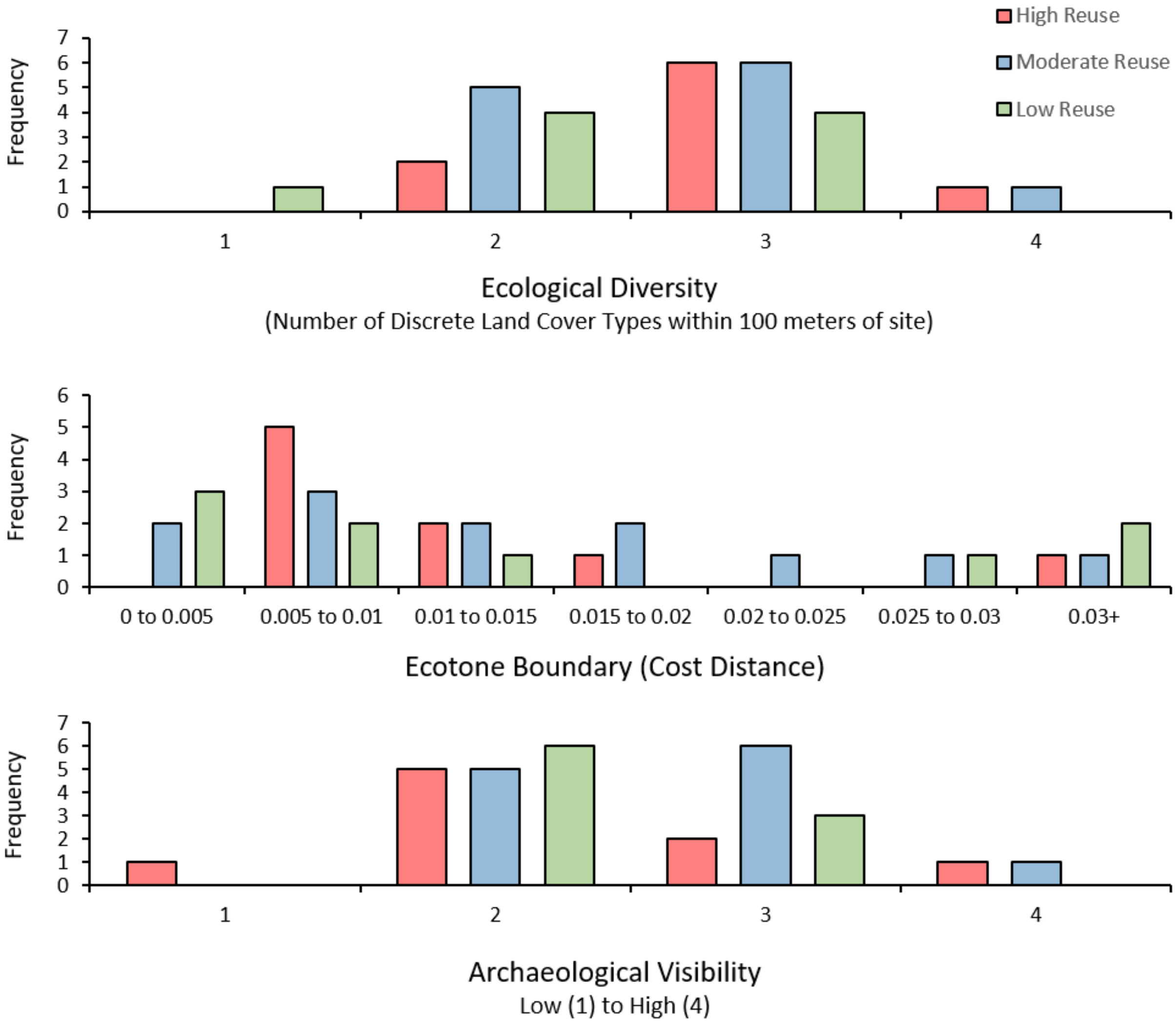


Figure 24. Frequency of site occurrence for ecological and visibility conditions. These variables account for strategic hunter-gatherer subsistence and settlement decisions, as well as the influence of visibility bias on the sample. Archaeological visibility can likewise be used to evaluate Schlanger's (1992) criteria for persistent place formation and the role of visible traces of previous occupations in reoccupation.

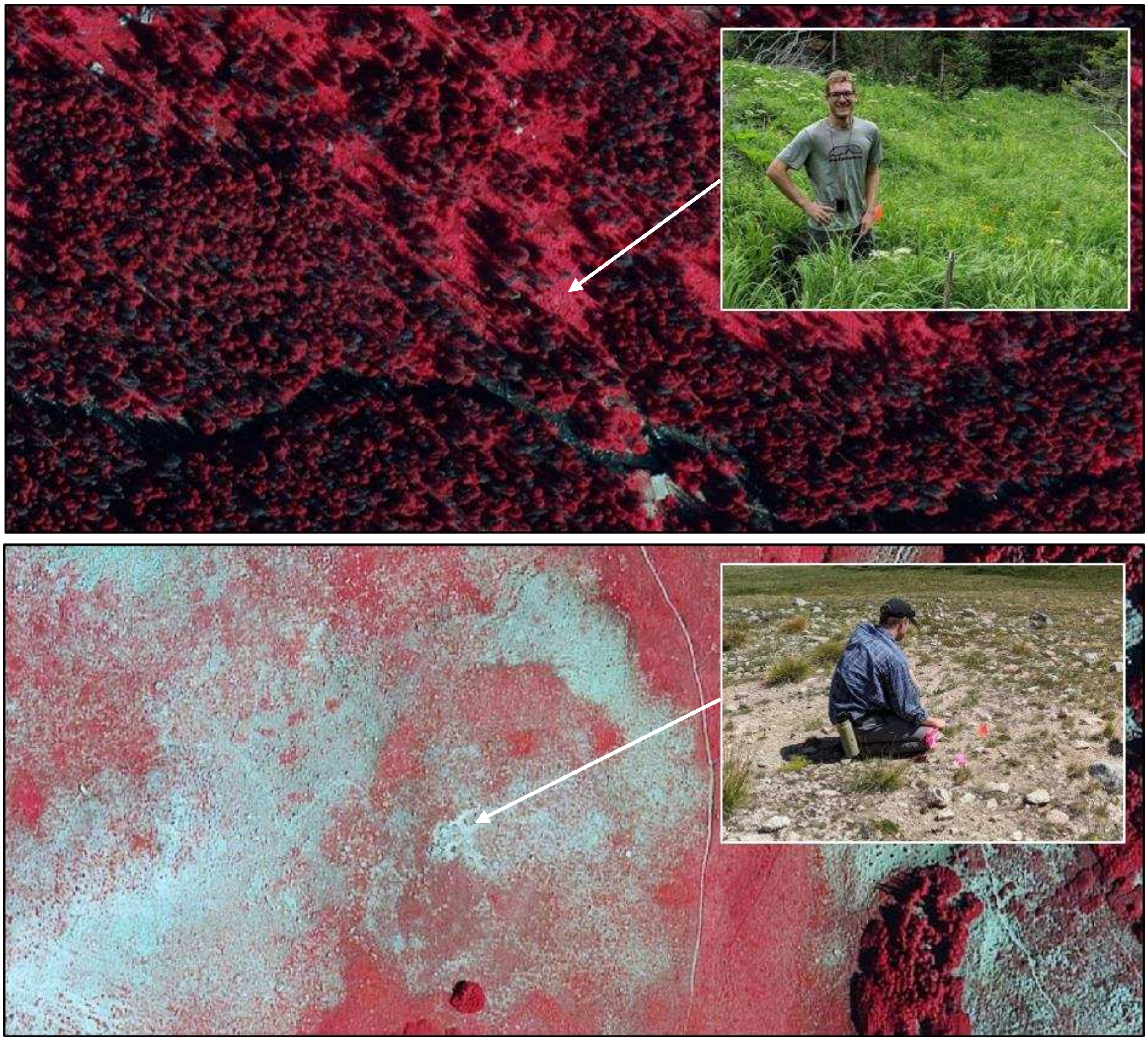


Figure 25. Variability in ground visibility across the study area. Background images show color-infrared (CIR) aerial imagery of sites 5LR17 (top) and 5LR240 (bottom). Dark red coloration indicates rapid growth of high density vegetation, while exposed sediments and bedrock appear as white. Inset Photographs: Archaeological crew members Matthew Ballance and Colt Johnson survey in variable ground visibility conditions (Buckner 2019).

The final variable, archaeological visibility, was created with several considerations in mind. Visibility bias is a common issue facing surface archaeology, and it is difficult to evaluate if a given landscape sample is representative of actual human behavior in the past, or simply optimal visibility conditions which allowed these sites to be more easily discovered (Wandsnider and Camilli 1992). Similarly, no formal survey coverage exists for the project area and absence data, where archaeological sites are *not* present on the landscape, is not available. For this analysis, where it is necessary to isolate behavior from visibility, it was critical to develop a methodology to account for these considerations and the possibility of visibility bias. Similarly, Schlanger's (1992) criteria for persistent place formation are dependent on the visibility of past material traces in a given place. For example, particularly in a raw material poor area, visible artifacts on the ground surface can attract additional occupations to a specific place and recycling of surface artifacts and raw materials (Camilli and Ebert 1992; Schlanger 1992). The discovery of these previous artifactual traces, and subsequent reuse of secondary raw materials, are largely dependent on surface visibility conditions (Camilli and Ebert 1992). For these reasons, archaeological visibility is both a necessary methodological consideration, as well as a critical component of understanding reoccupation and reuse of place.

To determine whether archaeological visibility biases were adversely influencing the sample, and whether reoccupation was centered around high visibility areas where previous artifactual traces were likely to be highly visible, an archaeological visibility proxy layer was developed. Previous field investigations indicate visibility in the high elevations of the Medicine Bow Mountains is mostly contingent on a) vegetation density and ground exposure, and b) animal burrowing activities (Buckner 2019; Meyer 2019b:3; Morris et al. 1994:70; Morris 2010:123). The northern pocket gopher (*Thomomys talpoides*), for example, is the most common burrowing mammal present in these high elevation environments (Winchell 2017). Pocket gophers burrow throughout the winter months, storing their backfill in subnivean snow tunnels which leave distinctive 'eskers' on the ground surface, and each *T. talpoides* is responsible for upwards of 2.25 tons of sediment disruption per year (Andelt and Case 2016; Bocek 1986; Pierce 1992; Winchell 2017). The enormous quantities of soil moved by these animals causes significant vertical movement in archaeological deposits, a site formation factor which exposes large quantities of artifacts in high elevation contexts (Bechberger 2010; Bocek 1986).

Figure 26. Eskers associated with Northern pocket gopher (*T. talpoides*) burrowing, pictured nearby to Carey Lake. *T. talpoides* store backfill in subnivean tunnels during the winter months, forming these distinctive 'eskers' which are exposed by melting snowpack (Andelt and Case 2016). Pocket gopher burrowing can bring large quantities of artifacts to the site surface. Photograph by Marie Matsuda for Buckner (2019).

To account for these visibility processes in the study area, such as vegetation density and *T. talpoides* activity, a geospatial data layer was constructed to estimate relative archaeological visibility. First, high resolution (0.3 meter) color-infrared (CIR) aerial imagery was procured for the study area (Figure 25). CIR imagery is a useful tool for measuring vegetation density and growth, and the multispectral bands reflected in CIR images contrast densely vegetated and thinly vegetated or bare areas (USDA 2013). The CIR data layer was resampled to a 10-meter resolution (necessary to match other data layers in the Maxent program), and reclassified into four visibility classes. These four classes were based on the light-to-dark spectrum represented in the imagery, where the darkest red areas represent dense and rapid growing vegetation and the lightest areas represent exposed sediments (USDA 2013). Next, a northern pocket gopher suitability raster was developed using land cover, slope, and soils data. Using a Weighted Overlay Analysis in ArcGIS, areas with soil deposition, slopes below 30°, and unforested meadows and alpine tundra were defined as suitable for northern pocket gopher habitation (Seabloom et al. 2000:26; Winchell 2017:23). The resultant *T. talpoides* raster layer coded each cell as ‘0’ (unsuitable habitat) or ‘1’ (suitable habitat). These two data layers, proxies for vegetation densities and northern pocket gopher habitat, were then overlain using the Weighted Overlay Analysis tool to create the archaeological visibility proxy layer. Ground visibility, as defined from analysis of CIR imagery, was weighted at 75% while pocket gopher habitat suitability was weighted at 25%. The resulting raster was incorporated into the model as an archaeological visibility raster to estimate the influence of visibility bias on the model, as well as the role of archaeological visibility in potentially encouraging reoccupation (Figure 27).

To ensure the above variables could effectively contribute to a high functioning model, it is critical to evaluate environmental variables for multicollinearity and redundancies. For example, if many of the variables are highly correlated it is possible that model outputs and variable contributions could be adversely biased (Dormann et al. 2013; Elith et al. 2010; Kalle et al. 2013:6; Feng et al. 2019; Noveillo et al. 2018:42). Pearson’s correlation coefficients are commonly used to identify these correlations in Maxent models (Benner et al. 2019; Buckner 2020; Chakraborty et al. 2016; Howey et al. 2016; Noviello et al. 2018). Once identified, redundant variables can then be removed through a step-wise process to optimize the model (Buckner 2020).

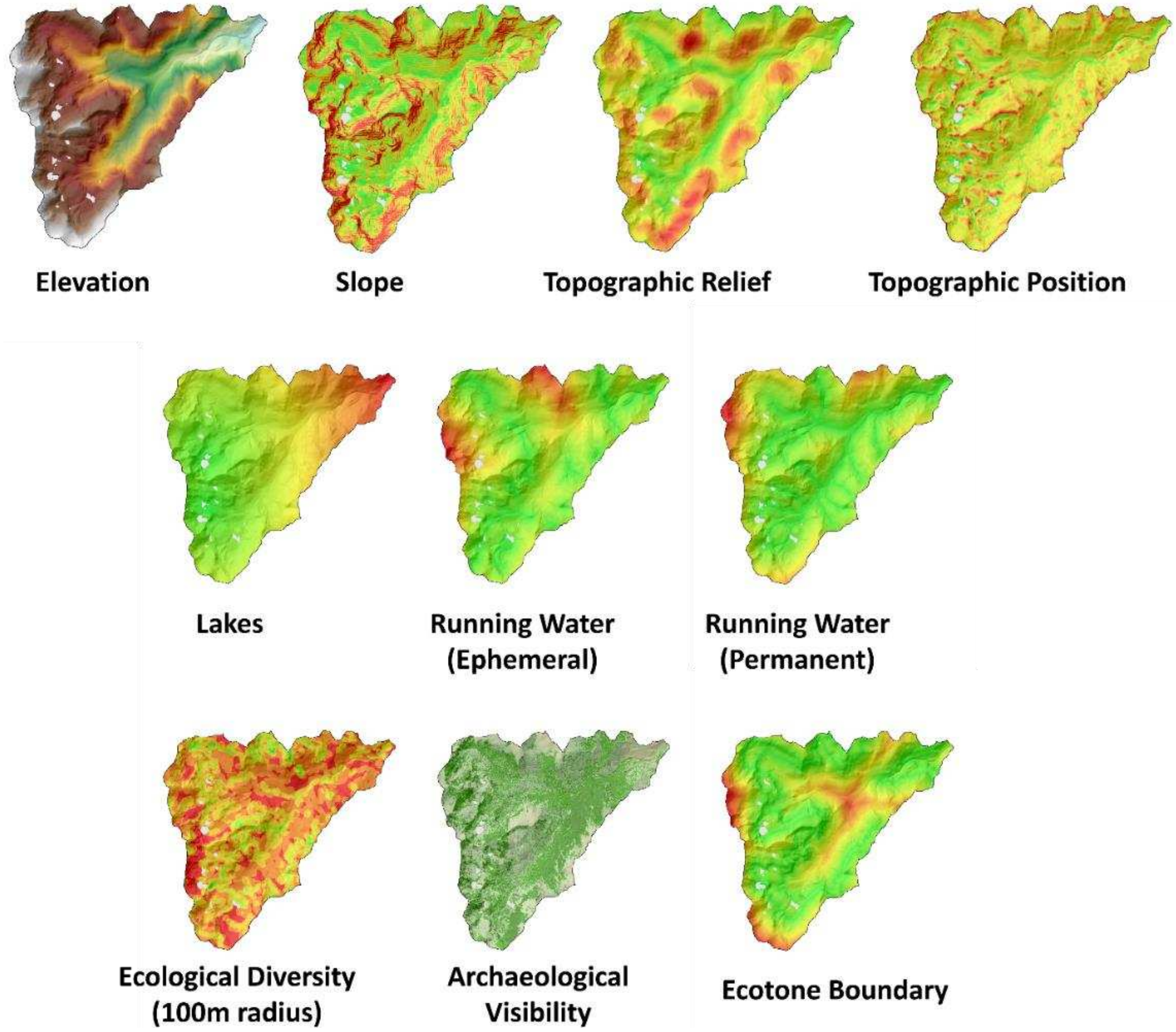


Figure 27. Environmental variables input into the Maxent models. These environmental layers were used to compare the ecological suitability for the occurrence of high reuse, moderate reuse, and low reuse sites. Color pallets reflect variation in variable values from low-to-high and are for illustrative purposes only.

In the case of the variables for this study, a correlation matrix analysis identified only a single statistically significant positive correlation. Nearly all the variables were found to be independent, which suggests that the selected variables will produce an effective and non-biased model. Just two variables were found to be significantly correlated, cost distance to ecotone boundaries and cost distance to lakes. While these variables are correlated at $p = 0.01$, the strength of this correlation was weak (Pearson's $r = .496$). Given that this mild correlation, both variables were ultimately retained. Neither lakes nor ecotone boundaries were removed from the analysis given their common importance for evaluating hunter-gatherer use of the high country, and the limited likelihood that they are redundant in their actual explanatory value. Similarly, though it is good practice to remove strongly correlated variables, Maxent's internal algorithm is designed to limit bias from correlated environmental variables and the inclusion of both is unlikely to significantly affect the outcome of the models (Dormann 2011).

Model Parameters and Technical Procedure

As with all computational methodologies in archaeology, spatioenvironmental modeling requires careful vetting of parameters to ensure models are as objective as possible. For this study, parameter selection was based on best practices for Maxent modeling in similar archaeological contexts, especially for previous studies which were oriented around understanding variation in settlement systems (Howey et al. 2016; Kailihiwa 2015; McMichael et al. 2013; Oyarzun 2016). Technical publications and statistical literature were also consulted to ensure the models were calibrated correctly (Elith et al. 2010; Phillips et al. 2006; Phillips 2017; Young et al. 2011). The parameters and settings ultimately selected for the model, based on these best practices, are shown in Table 7.

Each model was run 25 times and results were averaged. A bootstrap methodology was selected for the replicated run type and 20% of sites were removed with replacement from each run to develop the model's heuristic process. Though cross-validation has been used in place of bootstrapping in similar applications (such as Howey et al. 2016), the sample size for this analysis warranted use of a bootstrapping methodology. The number of model runs and regularization multiplier parameters were taken from Oyarzun (2016:30). A regularization multiplier of 5 was selected to minimize the potential for overfitting and an overly localized model (Phillips 2017). All other parameters were consistent with the default settings, which mostly govern model outputs and format of the model runs.

Table 7. Parameters and settings used to run the Maxent models for high reuse, moderate reuse, and low reuse sites. Settings were selected to maximize the functionality of the model while mitigating possible limitations from sample size and spatial autocorrelation.

Parameter	**Setting**	**Explanation**
Create Response Curves	*Enabled*	Creates probability plots for individual variables
Make Pictures of Predictions	*Enabled*	Generates a .png image of summary probability grids
Do jackknife	*Enabled*	Individual variables systematically omitted and tested in isolation
Output format	Logistic	Probability method used in writing output grid
Auto features	*Enabled*	Automatic limiting of feature types for small sample sizes
Basic Settings Tab		
Random seed	*Enabled*	Different random sample used for each replicate
Remove duplicate presence records	*Enabled*	Omits observations occurring in same grid cell
Write clamp grid when projecting	*Enabled*	Shows spatial distribution of clamping
Random test percentage	20	Percentage of sites removed for testing
Regularization multiplier	5	Multiplies regularization parameters by this number
Max number of background points	1,000	Maximum pseudo-absence background points used in testing
Replicates	25	The number of model runs averaged to create the final model
Replicated run type	*Bootstrap*	Sampling with replacement during model testing
Advanced Settings Tab		
Add samples to background	*Enabled*	Adds background points with combination of conditions not otherwise present among the background sample
Extrapolate	*Enabled*	Extends prediction beyond extent of training points
Do clamping	*Enabled*	Variables outside the training range treated as limit of the range
Default prevalence	*0.5*	Probability of prevalence at ordinary occurrence points
Experimental Settings Tab		
Logscale raw/cumulative pictures	*Enabled*	Logarithmic scale used for color-coding
Threads	*4*	Dependent on available CPU cores

Results: Landscape Modeling of Reoccupation

The Maxent results for high reuse, moderate reuse, and low reuse sites suggest the models were successful and a good fit for the data. The ability of the model to discriminate between a true positive (a known site test sample) and false positives (pseudo-absence background points), was used to calculate an area under the curve (AUC) score for each model. If a model has no gain over random chance, its AUC will be 0.5. A high functioning model, by contrast, should have an AUC close to 1.0. Each model reflected a high AUC score, including the high reuse model (0.92), moderate reuse model (0.95), and low reuse model (0.90). These AUC values correspond to an 80% to 90% relative improvement over random chance (0.5). An AUC at 0.90 or above reflects a model with "excellent" predictive capabilities and these models are considered highly efficient (Noviello et al. 2018:38; Swets 1988). Based on this benchmark, all three models were highly successful. Analysis of the accompanying receiver operating characteristic (ROC) curves likewise demonstrate that the models performed well (Figure 28). In a ROC plot, the model's averaged performance over 25 runs is shown by the red line, while the diagonal black line represents random chance. A model with a high predictive power will be as close as possible to the top left-hand corner of the plot area, indicating the model retains superior predictive power over random chance (Pearson 2010).

A secondary method for evaluating the effectiveness of each models is through analysis of the model residuals. Model residuals can be used to determine if the underlying assumptions behind the models are consistent with the results, estimate the statistical error of the models, and determine whether they are a good fit to the data (Daniel 2014). The residual is the difference between the estimated suitability of each cell and the observed suitability of each cell containing an observation (site). The Maxent model assigns a suitability value ranging from '0' (not suitable) to ‘1’ (suitable) to each raster cell. The observed value of cells with known sites is always ‘1’, as the cell is known to be suitable. Following Daniel (2014:24), the calculation for the raw residual is then represented as follows:

$$r_i = y_i - \pi_i$$

In this equation, the raw residual (r) for a raster cell (i) is equal to the observed suitability (y) of ‘1’ subtracted from the estimated (π) suitability value assigned by Maxent. If the model is performing as intended, and the underlying assumptions of the model are consistent with the results, the resulting raw residuals should be normally distributed (Dormann 2011:183). One method for evaluating the normality of residuals is through the use of Q-Q plots. If the data is approximately normally distributed, the raw residuals should closely align with the plotted straight line which represents a perfectly normal distribution (Dormann 2011). In the case of WBLR watershed models, the plotted raw residuals for each model are closely associated with the line representing a normal distribution (Figure 28). These results were confirmed with a Kolmogorov-Smirnov Test of Normality, where the raw residuals from the High Reuse (D = 0.157; p = 0.955), Moderate Reuse (D = 0.197; p = 0.673), and Low Reuse (D = 0.150; p = 0.970) models were found to *not* differ significantly from that which is normally distributed. The resulting p values allow us to accept the alternative hypothesis that the raw residuals are normally distributed and that the models are a good fit to the data.

From these results, we can determine that a) the models retain an excellent predictive and analytical capability, and b) the models are a good fit to the data with no evidence of significant compromising error. With confirmation that the models functioned properly and yielded accurate results, we can then turn to analysis of the environmental variables and their relative influence on suitability for sites from each reoccupation intensity category.

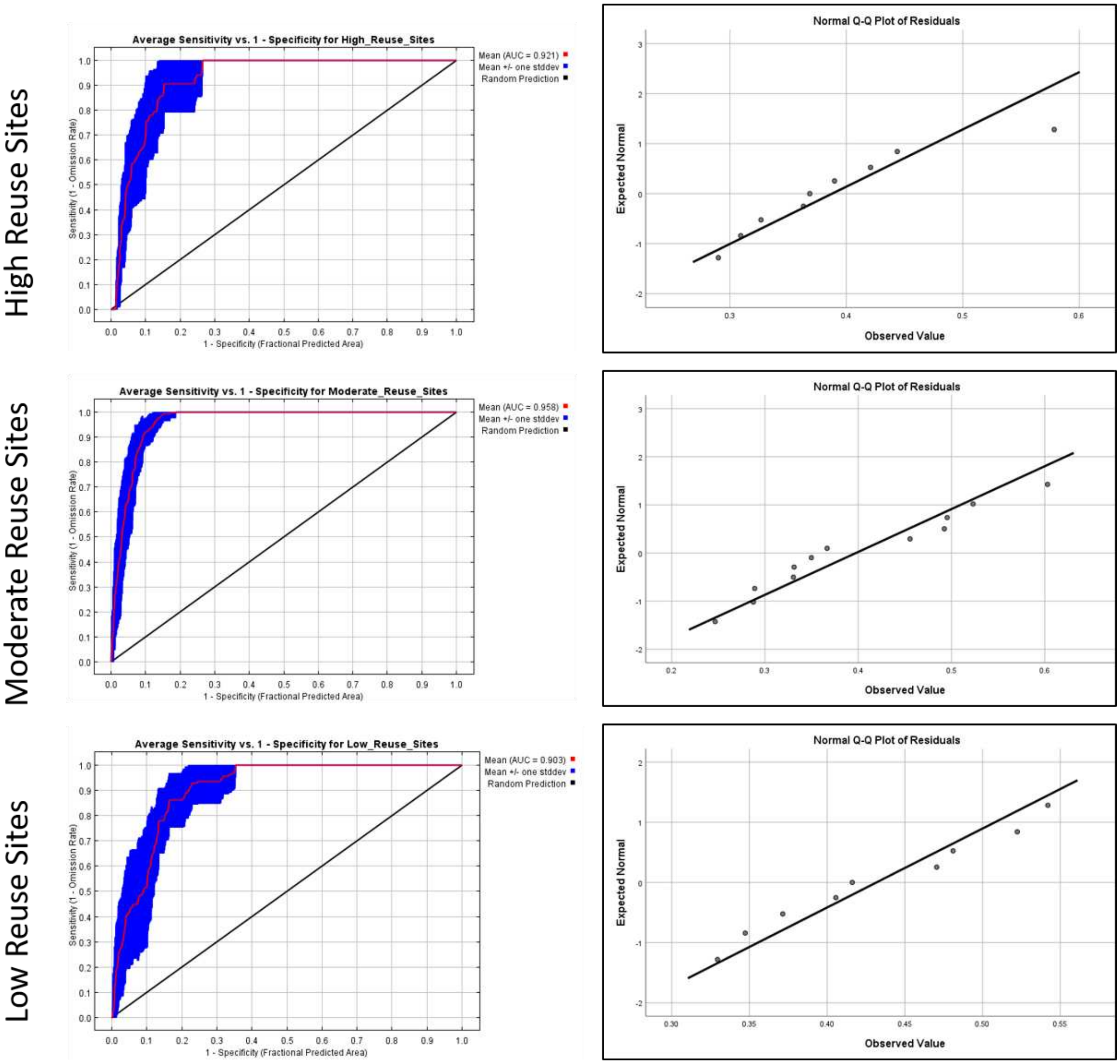


Figure 28. Receiver operating characteristic (ROC) plots (left) and Q-Q normality plots (right) for each model. ROC plots represent the ability of the model to discriminate between true positives and false positives. Normal Q-Q plots of model residuals identify whether the data are normally distributed. A normal distribution (shown by alignment of points along the line) of model residuals, which are the predicted value of a cell minus the observed (actual) value of a cell, suggests the model was a good fit for the data.

Table 8. Variable contribution and permutation importance values for each model. These values reflect the relative influence which environmental variable had on successfully predicting locations of sites. Variation between different reoccupation intensity classes suggests that there are differences in the environmental contexts which these site types are most commonly associated with.

	High Reuse		**Moderate Reuse**		**Low Reuse**	
Variable	Variable Contribution (%)	Permutation Importance (%)	Variable Contribution (%)	Permutation Importance (%)	Variable Contribution (%)	Permutation Importance (%)
Slope	95.4	97	43.6	38.6	65.4	65.7
Permanent Running Water	2.2	1.5	16.9	21.6	30.1	31.5
Ecotone Boundary	1	0.3	0	0	1.6	1
Elevation	0.8	0.8	0	0	0	0
Ecological Diversity	0.5	0.2	0	0	0.4	0.2
Topographic Relief	0.1	0.1	0.1	0	0	0
Lakes	0	0.1	35.5	33.7	1.8	0.8
Topographic Position	0	0	0	0	0	0
Temporary Running Water	0	0	3.1	5.4	0.1	0.2
Archaeological Visibility	0	0	0.9	0.6	0.6	0.7

.

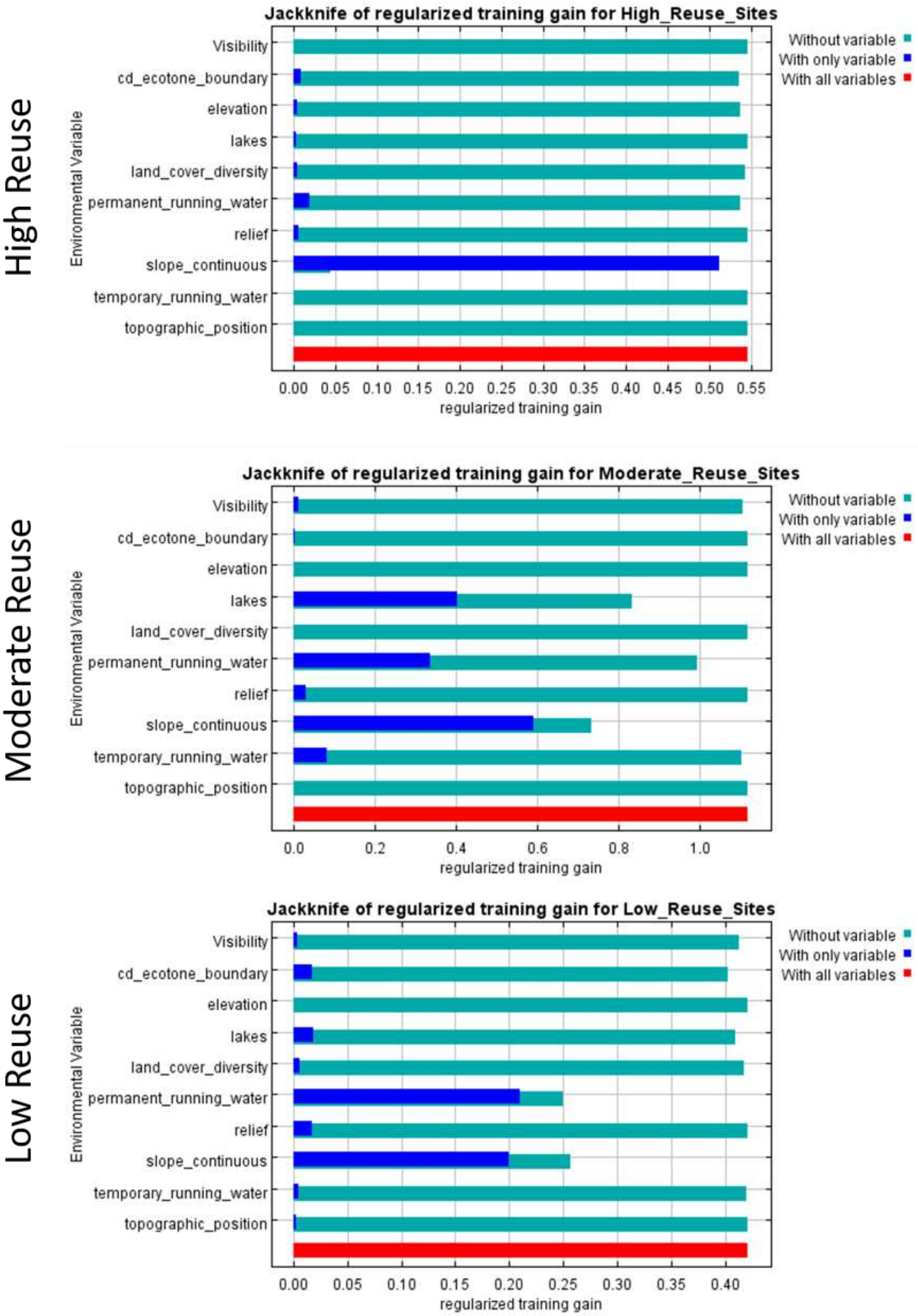


Figure 29. Variable jackknife charts for each of the WBLR models. These plots show the increase or decrease in training gain for each variable when the given variable is either a) removed from the model or b) used in isolation as the only predictor. Alongside permutation importance, these plots are used to evaluate variable significance.

Maxent has several outputs which yield useful metrics for analysis of these issues, including variable contribution and permutation importance tables, jackknife plots, and variable response curves. Variable contribution and permutation importance values, as seen in Table 7, are intended to quantify the relative contributions of each variable for each model. The variable contribution is calculated using the specific heuristic process undertaken by the Maxent algorithm, and can vary from run to run. The permutation importance, by contrast, is more stable and not subject to the same level of uncertainty (Kalle et al. 2013:6). For this reason, though variable contribution is useful for evaluating the process undertaken by the models, the permutation importance is the output which should be relied upon for analysis of the ecological contexts of the sites. In the case of the WBLR models, for example, we see substantive contrasts in the permutation importance of variables across the high reuse, moderate reuse, and low reuse site categories (Table 8). For high reuse, slope accounts for 97% of the permutation importance, indicating that there are few patterns associated with the permutation importance of these sites outside of their occurrence on flat slopes. Moderate reuse sites, by contrast, are influenced by a more diverse combination of environmental factors. For example, cost distance to lakes accounts for 33.7% of the permutation importance for moderate reuse sites. Sites with evidence of low reuse exhibit similar trends in variable importance as the high reuse sites. Again, slope comprises the significant majority of the permutation importance, at 65.7%. In contrast to the others, however, the cost distance to permanent sources of running water likewise contributes substantially to the model's ability to accurately predict suitability for these sites

To aid in interpreting the permutation importance and variable contribution values, Maxent likewise outputs variable jackknife charts (Figure 29). The model's internal jackknife tests are used to determine the individual variables which were most important to the model

(Elith et al. 2010). The Maxent program performs the jackknife test by sequentially omitting each individual variable from the model, and then running the model again with each variable as the sole environmental predictor (Kalle et al. 2013). The resulting increase or decrease in the model's training gain can then be interpreted alongside the permutation importance values to understand the importance of each variable for determining site suitability.

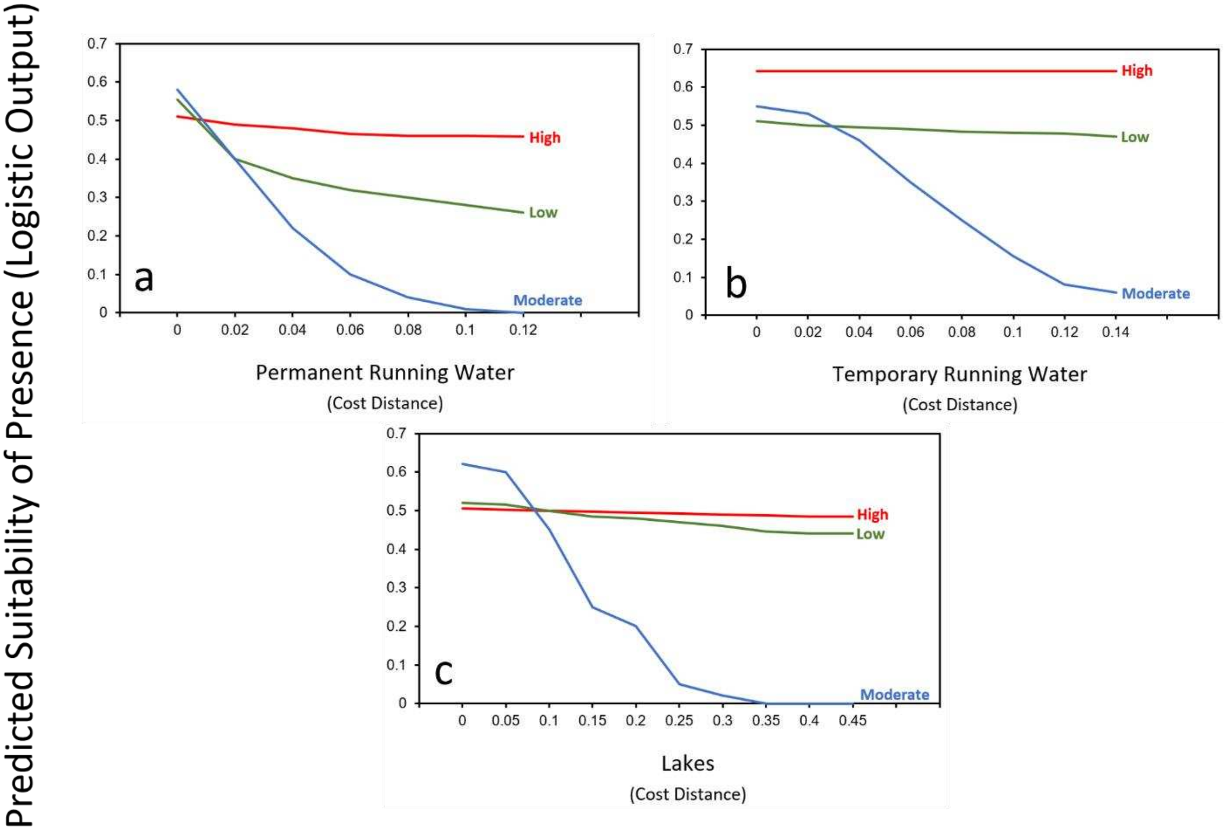


Figure 30. Response curves for water availability variables. These curves show the change in predicted site suitability (y-axis) in relation to cost distance to acccess water (x-axis) when the variable is used in isolation. A flat line indicates the variable has little influence on suitability, while a substantial increase or decrease suggests the variable substantively affects suitability.

The most valuable interpretive output of the Maxent program is variable response curves. These plots have the most utility for the identification and interpretation of contrasts in the environmental setting of different site categories (Howey et al. 2016; Walker 2019). The response curves show the probabilistic response of site occurrence to individual variables when used in isolation. Figure 30 for example, shows the individual response of each site category to water availability variables. The y-axis of each plot represents the predicted site suitability, while the x-axis displays the cost distance to access water. A flat response curve indicates that the variable has little predictive influence over the occurrence of that given site type. A response curve which significantly increases or decreases, in contrast, reflects a variable which is actively influencing suitability across different conditions. The permanent running water response curve in Figure 30a is an excellent example of this. As a variable, permanent running water is most associated with the distribution of sites with moderate evidence of reoccupation. There appears to be little influence of sites with high evidence of reuse, as indicated by a mostly flat curve. This should not be taken to indicate that sites with high evidence of reoccupation are not associated with permanent running water, nor that they would not depend on access to running water. Instead, variability in the high reuse sample suggests permanent running water was not the only significant factor governing settlement patterns. In contrast, across all three variables, we see evidence that moderately reoccupied sites were dependent on close access to water over other environmental factors. This generally complies with expectations from the initial analysis of the jackknife plots and permutation importance values. Response to water availability for high reuse and low reuse sites is likely attributable to increased variability in the location of these sites. While moderately reoccupied sites are consistently associated with water, rather than other environmental factors, with the exception of slope, the occurrence of high reuse and low reuse sites is more dynamic.

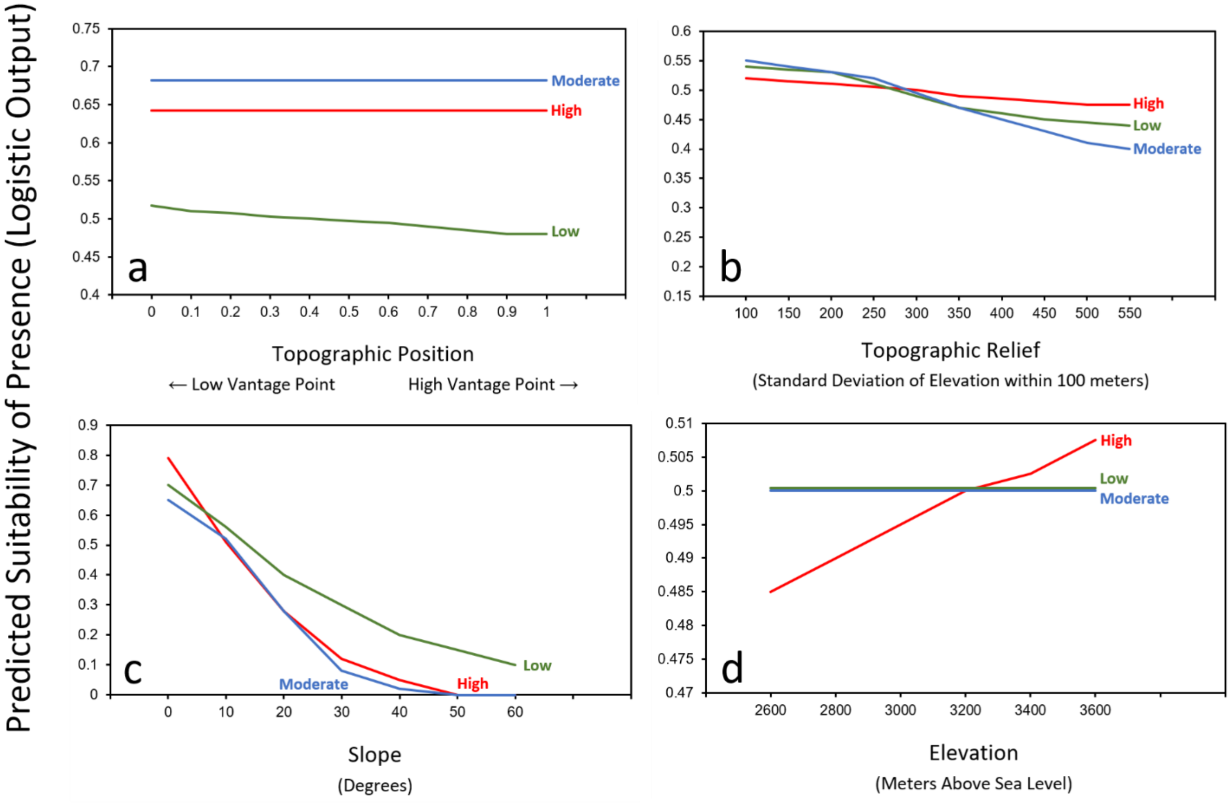


Figure 31. Response curves for geomorphology and terrain variables. These curves show the change in predicted site suitability (y-axis) in relation to variable values (x-axis) when used in isolation. A flat line indicates the variable has little influence on suitability, while a substantial increase or decrease suggests the variable substantively affects suitability.

Examination of the response curves for geomorphology and terrain variables is similarly informative. Apart from slope, many of these variables were inconclusive and had negligible influence on site occurrence. Slope largely fulfills expectations, as there is a steep decline in probability of site occurrence on slopes exceeding 10° (Figure 31c). Interestingly, low reuse sites do not respond as strongly to slope, likely because this category contains isolated finds which could correspond to hunting losses or accidental drops from moving through steeper terrain. Similarly, Morris and Metcalf (1993) and Morris et al. (1994) reported sites on steeper slopes as probable “kill sites”. By their nature, these sites would be highly ephemeral and would represent low reuse sites, possibly contributing to the lessened influence of slope on this category. Among the terrain variables, we also see a strong inclination for high reuse sites to occur at higher elevations (Figure 31d). Moderate and low reuse response curves are flat for elevation, by contrast, suggesting they are not significantly influenced. In the context of the WBLR study area, which covers 36.9 square kilometers with a minimum elevation of 2,620 meters (8,595 feet), the trend of reoccupied sites occurring at higher elevations could indicate they were the 'destinations' which people were traveling to when the entered the watershed. A more expansive analysis of persistent places from the plains to the alpine would likely not have a similar skew contingent on elevation, however the study area defined for this project is a snapshot of a wider high elevation landscape. Groups expending the high costs required to traverse this terrain were likely travelling to places on the landscape where they could access hunting grounds and procure alpine resources (e.g. Benedict 1992). This being the case, sites in the lower elevations in the study area would then be more likely to represent transitory stops on the way to these high elevation destinations. Over the wider ecological gradient from shortgrass prairie to alpine tundra, you should expect to see significant variability in transitory sites and destination camps occurring at different high and low elevations, but in this alpine/sub-alpine watershed context the evidence suggests these high altitude places constituted destinations for travel into the study area.

The response curves for ecological and land cover variables were similarly informative. The results of the cost distance to ecotone boundaries variable suggests that both high reuse and moderate reuse sites are more likely to occur in areas with low cost access to an ecotone boundary, while low reuse sites exhibited a lower probability of occurring nearby to an ecotone boundary (Figure 32a). Land cover (ecological) diversity likewise reflects similar patterns (Figure 32b). A flat response curve for moderate reuse sites suggests that variability in land cover and ecology did not substantively influence the occurrence of these sites. Closely aligned trajectories for high and low reuse sites indicates that this variable does not have sufficient explanatory power for discriminating between causation of preferential reoccupation.

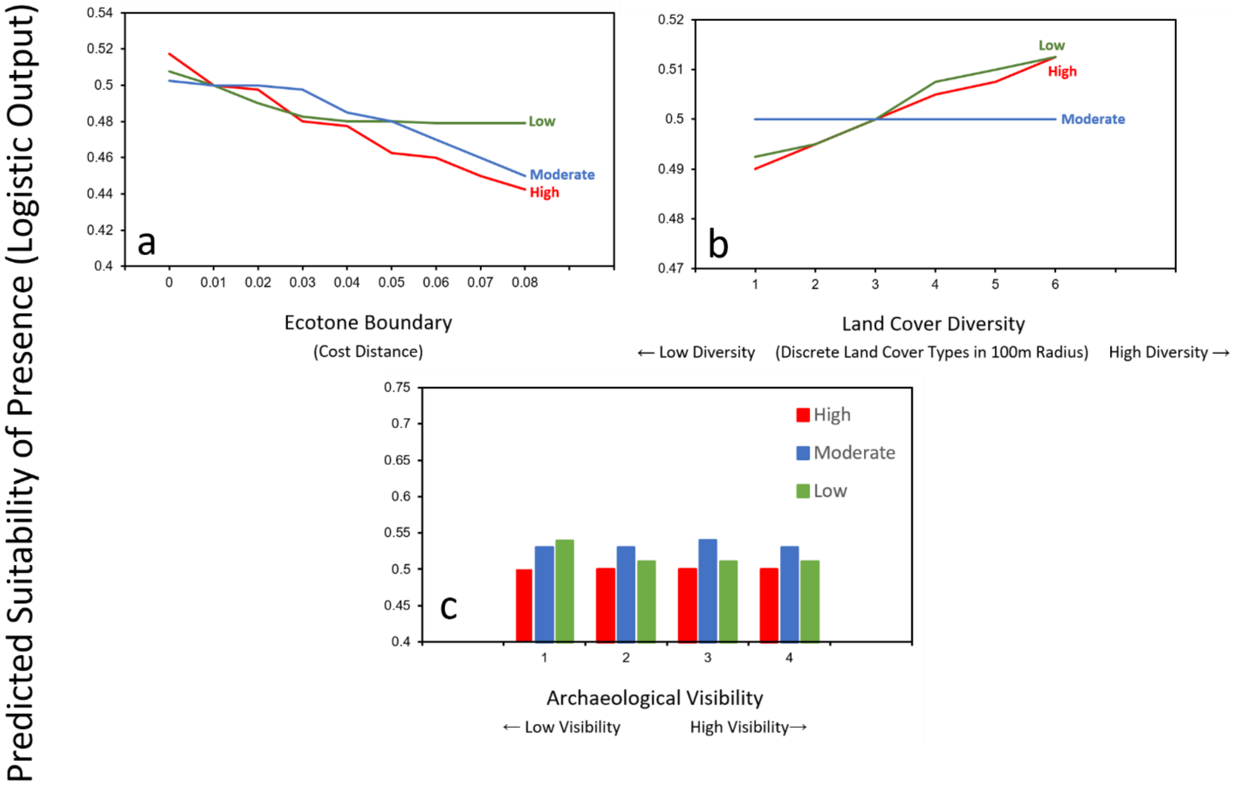


Figure 32. Response curves for ecology and land cover variables. These curves show the change in predicted site suitability (y-axis) in relation to variable values (x-axis) when the variable is used in isolation. A flat line indicates the variable has little influence on suitability, while a substantial increase or decrease suggests the variable substantively affects suitability.

The final variable in this category is the archaeological visibility proxy layer. This layer, which was intended to evaluate the potential bias of visibility on the sample and to determine if reoccupation was oriented around areas where artifactual traces of previous occupations would be most visible, appears to reflect little variability across the three models (Figure 32c). While there is some variance in the response of moderate and low reuse sites to visibility, though not significant enough to conclude there is a substantive bias in the sample, the high reuse model does not appear to have been influenced by the archaeological visibility proxy layer. For low reuse sites, including isolated finds, low visibility conditions were actually more suitable for occurrence. It is possible this may correspond to why fewer artifacts were found at these sites, or because they tend to occur at lower elevations with denser vegetation growth. In either eventuality, the results are fairly conclusive that archaeological visibility (as modeled for this study) did not significantly influence reoccupation or the discovery of sites.

Discussion: Spatioenvironmental Patterns of Persistent Reoccupation

Initial analysis of models for high reuse, moderate reuse, and low reuse sites indicates there is variation across each model but that relatively few significant differences exist. To determine if these differences are reflective of variation in landscape use, and reoccupation intensity, this section will critically evaluate the results in the context of the archaeological literature for high elevation archaeology. Sites with evidence for high reoccupation intensity, for example, were predicted to appear more frequently at high elevations and nearby to ecotone boundaries. In contrast, moderate reuse and low reuse sites were not significantly influenced by elevation and are less associated with access to ecotone boundaries. Similarly, sites with high evidence for persistent reoccupation do not appear to be associated within any singular type of water source, indicating that persistence is not necessarily tied to basecamps associated with high elevation lakes in the study area (Morris et al. 1994). This does not indicate that persistently reoccupied sites are *not* associated with access to water resources, rather it suggests that no one water source (lakes, permanent, or ephemeral) is singularly associated with suitability for these sites. To evaluate these broader trends and the most significant differences between high reuse sites and others, Benedict's (1981, 1985, 1992, 2000) work with the high elevation archaeology of the Colorado Front Range offers a useful comparative example.

The importance of the timberline ecotone in high elevation settlement systems is well recognized by archaeologists (Benedict 1981, 1992; Morris et al. 1994). The occurrence of sites in this distinct transitional ecotone is attributed to the shelter offered by krummholz stands, the last stands of encroaching trees at timberline, and the ease of access to both subalpine and alpine resources (Benedict 1992). A large number of significant multicomponent sites have been identified and investigated across the timberline ecotone, and the heightened suitability of persistently reoccupied sites to high elevations and ecotone boundaries in the study area points to similarities between these settlement systems. At the Caribou Lake site (5GA22) for example, Benedict (1981:107; 1992:8) speculated that the repeat occupation of the site was tied to its setting in sheltered area with ready access to firewood fuels. Benedict (1981) likewise suggested that the elevated position and viewshed of the site, and well-drained flat ground, were also advantageous environmental factors which encouraged occupation of the site. The Fourth of July Mine site (5BL153) was associated with similar environmental characteristics. As a palimpsest of episodic reoccupation, Benedict (2000) attributed the draw of the site to its setting in the timberline ecotone and access to high elevation hunting grounds. Additional multicomponent sites in the high elevations of the Front Range, such as the Coney Lake site (5BL94), 5BL70, and the Ptarmigan site (5BL170), are likewise all located in this timberline setting (Benedict and Olson 1978; Benedict 1981, 1990).

Though the geology and terrain of the Colorado Front Range is not a direct parallel to the Medicine Bow Mountains, there is a clear pattern which reveals a similar reoccupation emphasis on the timberline ecotone. This same pattern appears to hold true for the study area and the results of the spatioenvironmental model employed in this chapter. The Maxent results for high reuse sites suggest that reoccupied sites are strongly associated with a) high elevations and b) proximity to ecotone boundaries. While not constituting a ‘niche’ that entirely explains persistent reoccupation of place in the study area, it confirms that these conditions were important considerations in high elevation settlement systems. Schlanger's (1992) first criteria for persistent place formation describes the availability of optimal environmental conditions as one driver of reoccupation. As indicated by the results of the model, these environmental conditions encouraged preferential reoccupation and persistent place formation to at least some degree. Similar to Benedict's (1992) analyses of sites in the Front Range, there are patterns which suggest reoccupation was structured around the timberline ecotone and similar high elevation settings. Though Benedict (1981, 1990, 2000) also pinpoints access to alpine game drive systems as a factor in selection of these timberline camps, we can argue similar trends are at work in the Rawah Wilderness. As previously described, the placement of these high reuse sites suggests that they were a 'destination' for movements through the WBLR watershed. Though people were not occupying these sites in preparation for use of alpine game drives, such as in the Front Range, they were almost certainly utilizing campsites in this ecotone as logistical bases for alpine hunting and resource procurement. There are a number of high reuse sites which are not associated with the high elevations of the timberline ecotone. However these sites, 5LR235/5LR273/5LR274 and 5LR131, are located along the principle travel corridors (primary drainages) which do lead to these high elevation cirques. Reoccupation across various environmental contexts was certainly dynamic and by no means limited to the timberline ecotone, as these lower elevations sites suggest, however the model's support of similar patterns seen in the Front Range is compelling evidence for the preferential reoccupation of timberline and an emphasis on access to alpine resources.

In analyzing this data it is important to recognize the limitations of spatioenvironmental modeling studies, which could potentially influence these results. The use of contemporary environmental data as a proxy for paleoenvironmental conditions can be problematic. Howey et al. (2016) encountered this issue in their analysis of prehistoric monumentality and cultural processes using a Maxent methodology. Instead of considering modern variables as a direct corollary for the past, they evaluated the significance of these modern variables to "understand how areas across the landscape would have varied" in relation to one another in the past (Howey et al. 2016: 7445). Similarly, in his analysis of reoccupation of place on the Great Plains, LaBelle (2010:43) notes that sites with minimal evidence of reoccupation could "represent places where the particular resource[s] that might have drawn groups to the site […] were perhaps no longer there in subsequent periods". This is likewise an important consideration. Though analysis of local geology suggests there has been little change to the geomorphology of the study area since the terminal Pleistocene, there have been significant climatological shifts in the WBLR watershed through time (LaBelle and Meyer 2017; Workman et al. 2018a, 2018b). Though paleoenvironmental reconstruction was beyond the scope of the study, this study follows Howey et al.'s (2016) approach to use these data to understand how the landscape varied in relation to itself rather than assuming that modern conditions are a direct proxy to the past environment.

The results of the chapter suggest that reoccupation was variable, but a strong pattern exists to suggest that sites located at high elevations, and in close proximity to ecotones, were selectively reoccupied. While persistent reoccupation is certainly not limited to this specific environmental setting, the study suggests that there are reoccupation patterns similar to those observed by Benedict (1985, 1990, 1992, 2000) in the Rawah study area. Likewise, while these reflect one compelling pattern which contributes to our understanding of reoccupation, it is a near certainty that there were additional dynamics which could have guided preferential reoccupation of place in the study area. Though the archaeological visibility model created for this study was inconclusive, artifactual traces of past occupations, revealed by the heightened visibility of higher elevation areas, could have likewise structured reoccupation of these high elevation locales (Schlanger 1992). Though these other cultural and economic factors were not immediately apparent in the analysis conducted in this chapter, future analysis may clarify these further. For this study, the confirmation of high reoccupation intensity associated with the timberline ecotone is a significant step towards reconciling variability in landscape use across the high elevations of the Southern Rocky Mountains in northern Colorado. As an additional line of evidence, the preferential reoccupation of the timberline ecotone and high elevations of the study area reinforces the importance of alpine resources to the ancient inhabitants of the Medicine Bow Mountains.

CHAPTER 6 – RECOGNIZING REOCCUPATION IN SURFACE CONTEXTS

This chapter addresses the spatial character of reoccupation in high elevation surface contexts. The previous two chapters have outlined the assemblage composition and landscape characteristics of preferential reoccupation, and this third analysis will contribute an important spatial and site structure component to the holistic study of reoccupation in these environments. Under Schlanger's (1992) framework for persistent places, sites may be selected for repeat reuse when (1) optimal environmental conditions exist, (2) past artifactual traces are visible on the landscape, or (3) when existing cultural features at the site allow it to be reoccupied at reduced cost. Each of these criteria outlined in Schlanger (1992) should be apparent in the spatial structure of sites, and the spatial relationships between discrete occupations can be used to identify the nature of the reuse of the site. A site-level analysis of these reoccupation criteria in the Medicine Bow Mountains, however, is complicated by the nature of high elevation archaeological analyses. The time-averaging of deposits through frost-heaving, sediment deflation, bioturbation, artifact collection, and erosion are common challenges which affect analysis of surface archaeology associated with hunter-gatherer sites. Despite these obstacles, in the alpine and elsewhere, the archaeological surface record constitutes "an appropriate source of data independent of subsurface remains" which can yield valuable information on the structure of archaeological sites (Dunnell and Dancey 1983:70). Surface archaeology, though often valued less than subsurface data, has also been recognized for its "intrinsic interpretive potential" and as an "indispensable component of modern settlement archaeology" (Downum and Brown 1998:111; Sullivan 1998:XI). Though there are certainly visibility and interpretive challenges to interpretation of these data, this interpretive potential posed by surface artifact distributions remains high (Kvamme 1998; Simmons 1998; Wandsnider and Camilli 1992). Particularly with the analytical power of modern GIS analyses, it is possible to capitalize on this potential to apply qualitative and quantitative means to examine the structure and spatial character of time-averaged deposits. The principal objective of the chapter is to evaluate the character of palimpsest deposits in the context of reuse and persistent reoccupation of place. In addressing this objective, the chapter confronts three primary questions. First, to what degree is reoccupation recognizable from surface contexts? Second, how is reoccupation reflected spatially in the distribution of artifacts at sites? And, third, how does variation in artifact distributions inform analysis of reoccupation?

Methodology: High Resolution Mapping and Surface Analysis of Reoccupied Sites

The discrimination of discrete occupations from time-averaged deposits is, by the very nature of a palimpsest, a significant challenge. To accomplish this, sophisticated means of spatial analysis are required. In Sullivan's (1992:100) spatial analysis of short-duration occupations in a complex surface context, he recognized the necessity of dissecting larger artifact distributions to define "subsite areas" which could be used to "identify and monitor variation among occupations." This is most commonly actualized through examination of clusters, or high density concentrations of artifacts, and such techniques are commonly applied to evaluate reoccupation or contemporaneity at sites. Burnett (2005) applied cluster analyses of artifact density, tool diversity, and lithic raw material variability to evaluate divergent chronological trends at high elevations. In Andrews et al. (2008), analysis of clusters was used to examine variability among the spatial structure of Folsom sites, alongside discrimination of reoccupied sites from single component sites. Meyer (2019a) analyzed discrete feature and artifact concentrations to decode a complex series of reoccupation episodes comprising an alpine game drive system. Specialized spatial analysis of clusters is especially necessary as archaeological analysis of time-averaged sites can often be hampered by the "application of inappropriate interpretive frameworks that […] assume that spatially separate deposits are contemporary" (Shiner 2009:25). As demonstrated by these examples, the identification of clusters on the surface of sites is a critical first step in carrying out any spatial analysis of reoccupation.

Figure 33. Scenes from Rawah Wilderness fieldwork in 2019. Clockwise from top left: Crewmembers intensively survey 25-meter by 25-meter sampling grids for surface artifacts, volunteers map and document artifacts with a high resolution Trimble GNSS device, graduate student Marie Matsuda takes overview photographs, and an evening scene from field camp. Photographs by author (See also Buckner 2019).

To acquire the necessary data to identify clusters and assess the spatial character of reoccupation, an intensive fieldwork program was carried out in the summer of 2019 (Buckner 2019). A total of six localities, identified previously as reflecting high evidence of reuse, were selected for field investigation (Table 9). Sophisticated geospatial analyses of clusters require high-resolution datasets of piece-plotted surface artifacts, and acquiring these data was a critical objective of fieldwork (Buckner 2019; Hurst et al. 2010). To accomplish this, selected sites were intensively sampled with 25 meter by 25 meter sampling grids and shoulder-to-shoulder transect intervals. This sampling methodology has proven to be effective for surface analysis of large debitage scatters, and these strategies are advantageous for "ensur[ing] uniform surface coverage and eliminat[ing] artifact discovery biases" (Kvamme 1998:139). The Center for Mountain and Plains Archaeology has likewise successfully applied these strategies in other high elevation contexts, such as in the Colorado Front Range and at the Carey Lake site (5LR230) in the Rawah Wilderness (LaBelle and Pelton 2013; Meyer 2019b; Whittenburg 2017).

All artifacts encountered in sampling areas were flagged, mapped in place with high resolution GNSS equipment, and documented on specialized data forms (Buckner 2019). All geospatial data was collected with sub-meter accuracy and at a decimeter resolution using a Trimble Geo7x device and accompanying geodetic antenna. Basic descriptive metrics were also recorded in the field for each artifact, including artifact class/element, maximum length (mm), presence/absence of cortex, presence/absence of thermal alteration, and lithic raw material type. Similar to the previous discussion of lithic raw material types in Chapter 2, each raw material type was field classified based on a visual macroscopic analysis (e.g. white chert), but artifacts were then grouped into broader analytical categories (e.g. CCS or quartzite) with low subjectivity to minimize error (See Chapter 2). These methods are also detailed in Buckner (2019), the technical report prepared for the USDA-Forest Service on the results of the author's fieldwork in the Rawah Wilderness. Formal tools and diagnostic items were collected in the field for laboratory analysis and permanent curation, while informal tools received additional documentation but were not collected. Following completion of fieldwork, all geospatial data was differentially corrected to resolve minor plotting inaccuracies and to ensure the integrity of the data sample (Buckner 2019).

Table 9. Sites, with high evidence of reuse, selected for field investigation in 2019. Sites are shown in order of their investigation (Buckner 2019). See Chapter 4 for analysis of pre-2019 collections and identification of sites with evidence of probable reuse.

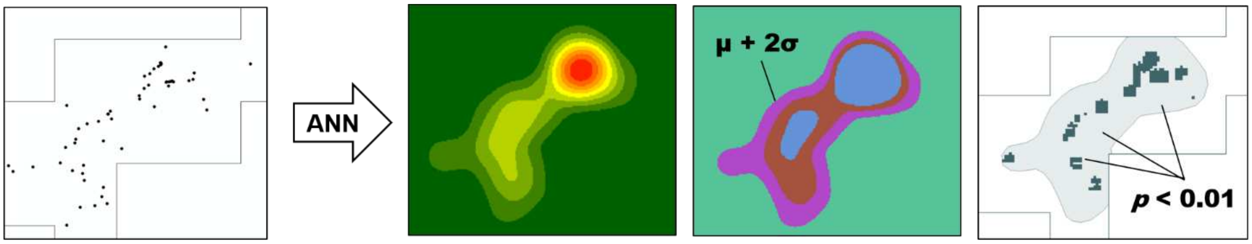
Locality / Site	Elevation (m)	Assemblage Size (n)*	Known Components*
5LR235 / 5LR273 / 5LR274	2,910	824	1
5LR153 / 5LR237	3,335	298	1
5LR229	3,365	21	2
5LR233	3,455	33	1
5LR240	3,415	66	3
5LR174	3,260	160	3

*Values are from extant collections discussed in Chapter 4.

Following collection of field data, it was then necessary to analyze artifact distributions for the presence of discrete clusters. To define these clusters, a mixed methodological approach incorporating various techniques from Burnett (2005), Brunswig and Diggs (2014), Morgan et al. (2013), and Stavrova et al. (2019) was applied. First, the Average Nearest Neighbor (ANN) tool from ArcGIS was run on each mapped site to determine if significant dispersion or clustering of artifacts exists within the surface distribution of artifacts at each site. Once statistically significant clusters were found to exist at a site, the boundaries of these clusters were then defined using the Kernel Density Estimation (KDE) tool in ArcGIS. KDE analyses use a quadratic kernel formula to generate a probabilistic density surface based on the fit of a smoothed interpolated surface around each point (Silverman 1986; Stravrova et al. 2019). These analyses have numerous applications in archaeology, though they are most commonly applied for visualization of contrasting high density and low density areas (Baxter and Beardah 1997;

Beardah 1999; McMahon 2014; Stravrova et al. 2019). In the context of the WBLR investigations, KDE was applied to define discrete areas where significant quantities of artifacts were concentrated (clusters). This was performed by reclassifying the default KDE output surface from a continuous probabilistic density raster to a standard deviation density raster. Then, areas within the site with artifact densities exceeding two standard deviations from the mean were selected to define cluster boundaries. These clusters, following Burnett's (2005) example, were selected for further analysis if five or more artifacts were present within the cluster. Though the use of standard deviations in artifact density to define clusters is arbitrary, there is some basis for this in other forms of statistical spatial analysis (Stavrova et al. 2019). Likewise, definition of clusters based upon KDE relative densities is suitable for discriminating these concentrations when an ANN analysis has previously confirmed clusters exist among the distribution. However, to confirm the statistical validity of the KDE defined clusters, a secondary hot spot analysis was also applied. Hot spot analysis uses the Getis-Ord Gi* statistic to identify significant 'hot' and 'cold' spots in artifact distributions, and is likewise an effective tool for distinguishing artifact clusters from a lithic landscape (Brunswig and Diggs 2014). Such hot spot analyses have been shown to be especially useful for identifying "areas of very intense artifact clustering" while eliminating areas which appear to be clustered but are not actually statistically significant (Brunswig and Diggs 2014:85). Hot spot analysis faces some limitations, in that it requires a minimum of 30 data points, however the ArcGIS Optimized Hot Spot Analysis tool incorporates useful features which define appropriate scales of analysis and minimize the potential for user bias (Stavrova et al. 2019). Given the importance of correctly defining clusters for this scale of analysis, only clusters confirmed by the hot spot analysis were included in interpretation of artifact distributions. The Optimized Hot Spot Analysis tool likewise outputs a

p-value which can be used to test a null hypothesis (no clustering exists) against a predetermined confidence interval. In the case of validating the clusters identified through the ANN and KDE analyses, a confidence interval of 99% was chosen ($p > 0.01$) to accept or reject the null hypothesis. Through this procedure, it is then possible to discriminate clusters from complex lithic landscape contexts for intensive analysis of the spatial character of palimpsest deposits.



Field Data Sample

Raw KDE to Show Relative Density

Reclassified KDE to Define Cluster Boundary

Statistical Validity of Cluster Confirmed with Hot Spot Analysis

Figure 34. Graphical representation of the procedure used to define clusters in surface artifact distributions. Once clustering was determined to exist at a site, using the Average Nearest Neighbor (ANN) tool, the Kernel Density Estimation (KDE) tool was used to define cluster boundaries. Boundary definition was performed by isolating areas with artifact densities greater than two standard deviations above the mean. Cluster boundaries were then validated using the Optimized Hot Spot Analysis tool, which was tested with a 99% confidence interval ($p < 0.01$).

Results: Spatial Analysis of Surface Artifact Distributions

During 2019 fieldwork, 5.21 hectares were sampled with intensive shoulder-to-shoulder transects across the six localities. A total of 263 artifacts were mapped and 17 formal tools were collected from additional analysis from these sites (Buckner 2019). The results of the 2019 fieldwork were variable between the various localities investigated, and the quantities of artifacts identified were highly variable (Table 10, Figure 35). Three localities yielded more than 50 surface artifacts, while surface artifacts identified at the remaining three localities ranged between just one and seven items. Archaeological visibility was likely a determining factor is the number of surface artifacts identified, with the possible exception of 5LR229, as the sites which yielded the most artifacts were all located in the alpine ecozone and timberline ecotone where less deposition and low vegetation exposes artifacts. In contrast, sites which yielded few artifacts were exclusively located in the densely forested subalpine ecozone where forest detritus and surface vegetation obscure the ground surface (Buckner 2019).

Table 10. Summary table of sampled area, mapped items, and collected artifacts from sites investigated in 2019. Sites 5LR17 and 5LR14336 were also visited, but are not included in this analysis (See Buckner 2019).

Locality / Site	Area Sampled (ha)	Mapped Items	Artifacts Collected
5LR235 / 5LR273 / 5LR274	0.62	1	0
5LR153 / 5LR237	1.44	103	7
5LR229	0.56	5	0
5LR233	1.25	80	3
5LR240	0.87	67	6
5LR174	0.44	7	1
Total	**5.21**	**263**	**17**

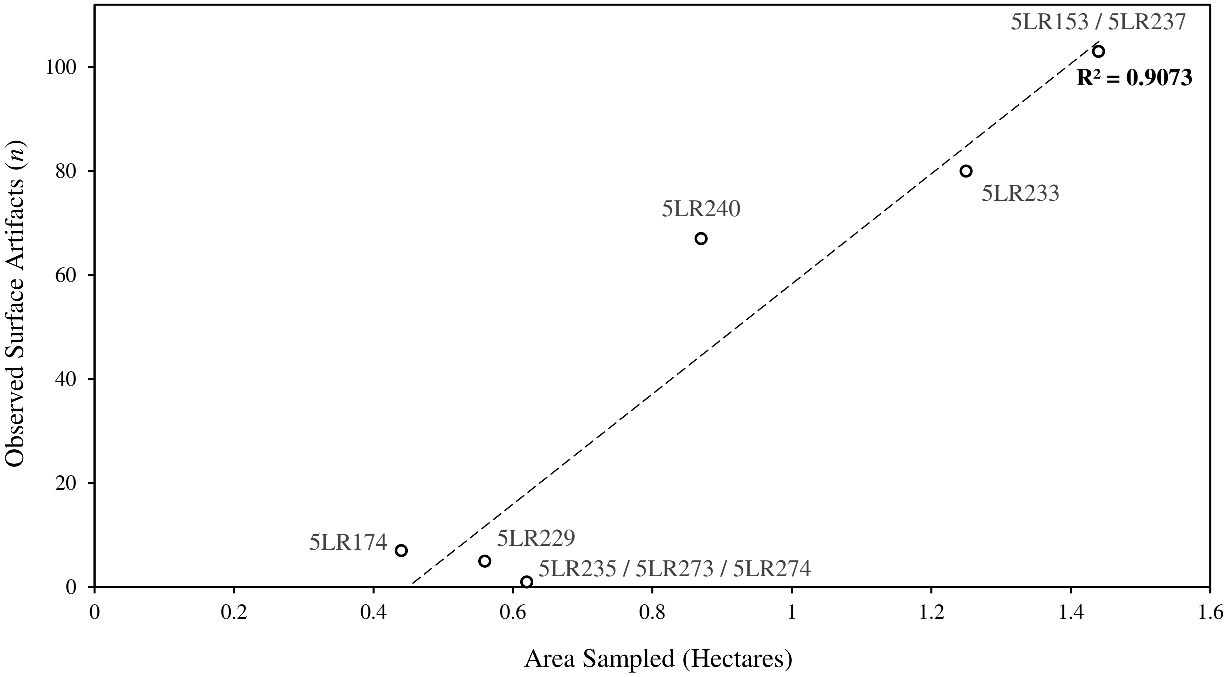


Figure 35. Observed surface artifacts by total area sampled at each locality. Three sites yielded more than 50 surface artifacts, while visibility conditions imposed substantial limitations on surface investigation of the three remaining localities. See Buckner (2019a).

Given the significant visibility issues impacting the three least productive sites, only localities which yielded 50+ artifacts could be analyzed for the presence of clusters. Similarly, the Optimized Hot Spot analysis tool could not be applied to sites with fewer than 30 artifacts, and these sites (5LR174, 5LR229, 5LR235/5LR273/5LR274) were therefore omitted for further analysis (Stavrova et al. 2019). Of the sites which did yield samples suitable for spatial analysis, all three returned ANN determinations which indicated statistically significant clustering exists on the surface of these sites (Table 11). The sites, the Twin Crater Lakes site (5LR153/5LR237), 5LR233, and the Grassy Pass site (5LR240), are located at high elevations in the alpine ecozone or alpine/subalpine timberline ecotone. As discussed in Chapter 4 each site's pre-2019 assemblage was analyzed for reoccupation signatures and each site was found to exhibit high evidence of episodic reuse. One site, Grassy Pass, has a minimum of three known components based on this analysis, while the other two sites have suggested evidence of reoccupation but no non-contemporaneous diagnostic artifacts in extant collections. Two of the sites are likewise located nearby to high elevation lakes, while 5LR240 is situated in the context of a pass. Collectively, these three sites constitute an adequate sample for evaluation of the spatial character of reoccupation and structured reuse of place.

Table 11. Results of the average nearest neighbor (ANN) analysis. The nearest neighbor ratio values indicate that statistically significant clusters of artifacts exist on the surface of each site which yielded 50 or more surface artifacts.

Locality / Site	Expected (m)	Observed (m)	NN Ratio	*p*-value	Determination
5LR153 / 5LR237	4.773	3.239	0.678	0.000	Clustered
5LR233	6.251	4.057	0.650	0.000	Clustered
5LR240	4.795	3/811	0.795	0.001	Clustered

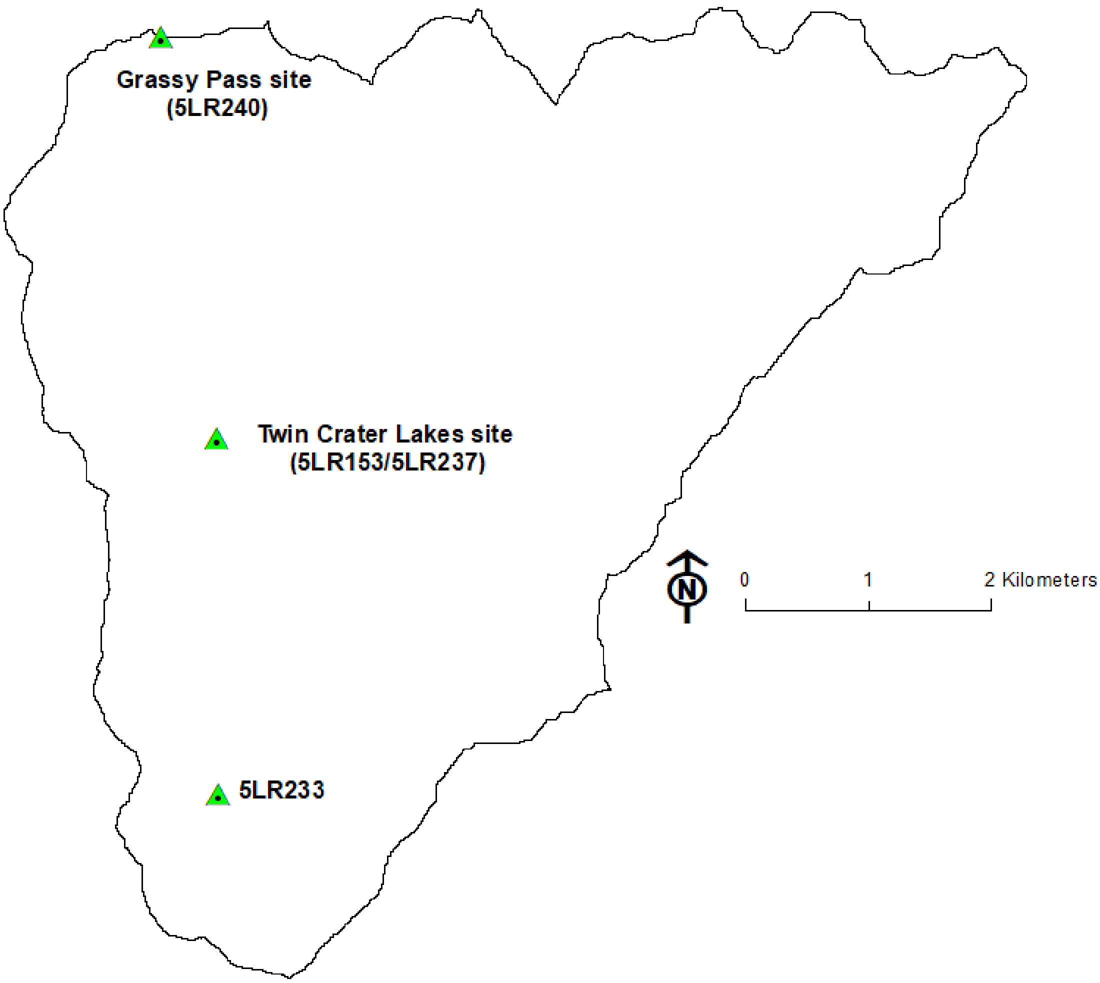


Figure 36. Locations of sites described in this chapter. The sites, located in the alpine ecozone and timberline ecotone, represent a longitudinal north-to-south sample across the wider WBLR watershed. Background contextual information is not shown to protect site locations.

Twin Crater Lakes (5LR153 / 5LR237)

The Twin Crater Lakes site (5LR153/5LR237) was first recorded by Metcalf (1971a, 1971b) during Colorado State University's early investigations in the Rawah Wilderness in the early 1970's. The site was originally documented as two distinct sites, however their close proximity of less than 30 meters warranted their consolidation for the 2019 analysis (See discussion in Chapter 2). The Twin Crater Lakes site is located in the timberline ecotone, at an elevation of 3,335 meters above sea level. The site is associated with the Twin Crater Lakes, which are among the largest high elevation lakes in the study area. Metcalf's (1971b) first visits to the site yielded several Mount Albion corner-notched projectile points, though they were not recognized as such until after Benedict and Olson's (1978) identification of the complex. Metcalf (1971b) recognized the potential of the site for further analysis, and described it as "more promising than all others" in field notations. In Morris et al.'s (1994) synthesis of nearly 30 years of Rawah archaeology, they identify a Late Archaic component at 5LR153 and Early and Late Archaic components at 5LR237. The multiple component nature of these sites could not be substantiated through analysis of projectile point bases in the existing collections, however the sites reflect high diversity of tools and lithic materials which suggest they may represent multiple components. Morris et al. (1994) may have been referencing projectile point fragments (such as 5LR153-118; See Appendix A), which were not assigned to a definitive temporal period by this study. In either case, there is strong evidence to suggest that the Twin Crater Lakes site represents a persistently reoccupied high elevation context, and spatial analysis of artifact distributions is a powerful tool for clarifying the extent and nature of the reuse of the site.

The 2019 investigations at the Twin Crater Lakes site sampled an area totaling 1.44 hectares, and 103 artifacts were identified and mapped on the surface of the site (Buckner 2019). A large number of formal lithic tools were likewise identified on the site surface and collected for further analysis, including projectile points (n = 3), preforms (n = 3), and a biface fragment (n = 1). Informal tools were limited to a single edge modified flake which was not collected (Buckner 2019). Debitage was comprised of 95 artifacts, and excellent ground visibility allowed for identification and mapping of artifacts as small as 4 millimeters in length. Lithic raw material types across the site surface were mostly comprised of CCS materials (93.2%) with smaller amounts of quartzite (6.8%) (Buckner 2019).

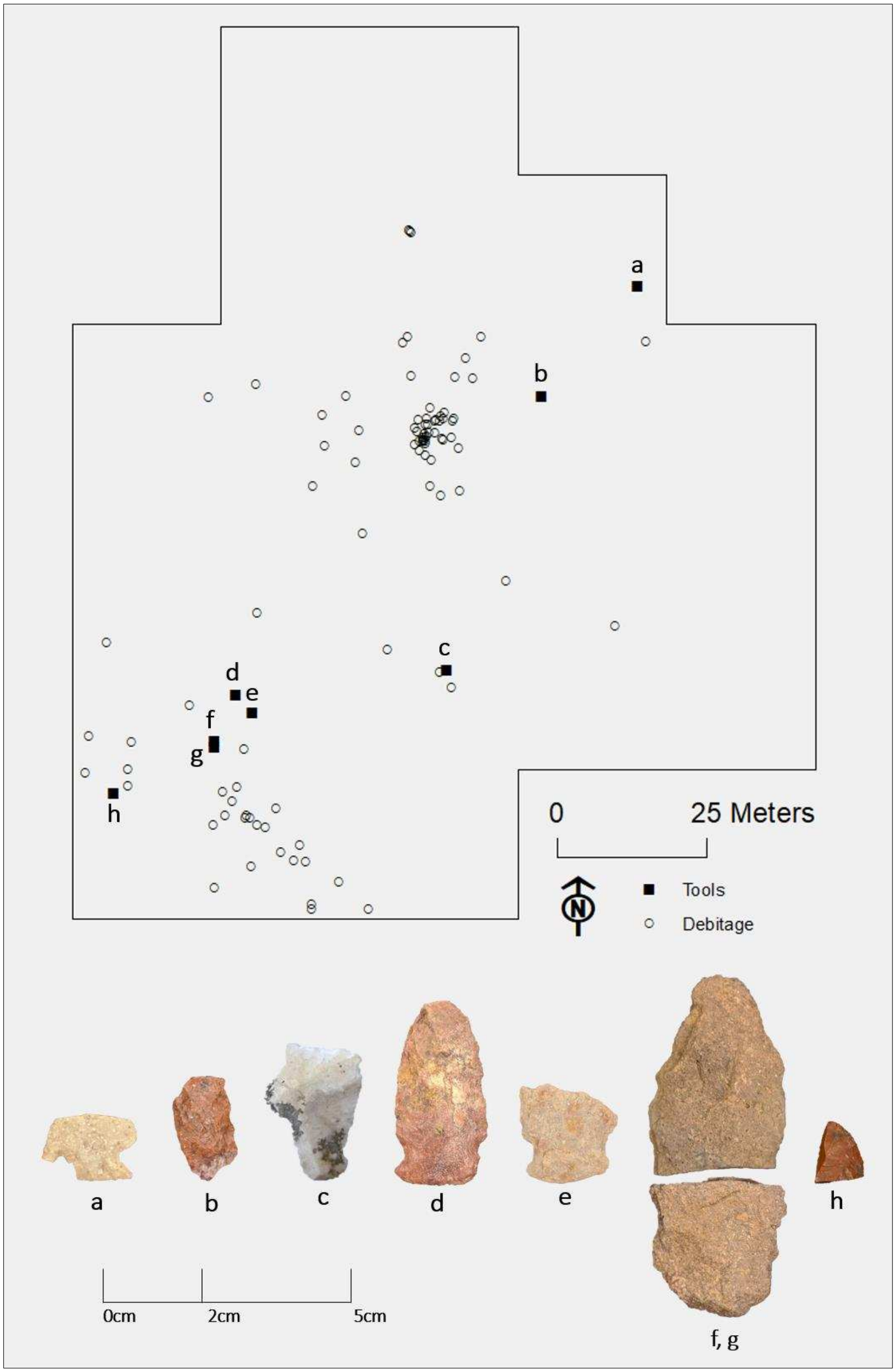


Figure 37. The results of intensive sampling at the Twin Crater Lakes site (5LR153/5LR237). Identified tools include a Late Archaic Pelican Lake projectile point (**a**; 5LR153/5LR237-2019-97), a preform fragment (**b**; 5LR153/5LR237-2019-98), an edge modified flake (**c**; 5LR153/5LR237-2019-103), Early Archaic Mount Albion projectile points (**d**; 5LR153/5LR237-2019-99; **e**; 5LR153/5LR237-2019-100), a refit preform (**f**; 5LR153/5LR237-2019-102 (distal); **g**; 5LR153/5LR237-2019-101 (proximal)), and a biface fragment (**h**; 5LR153/5LR237-2019-1).

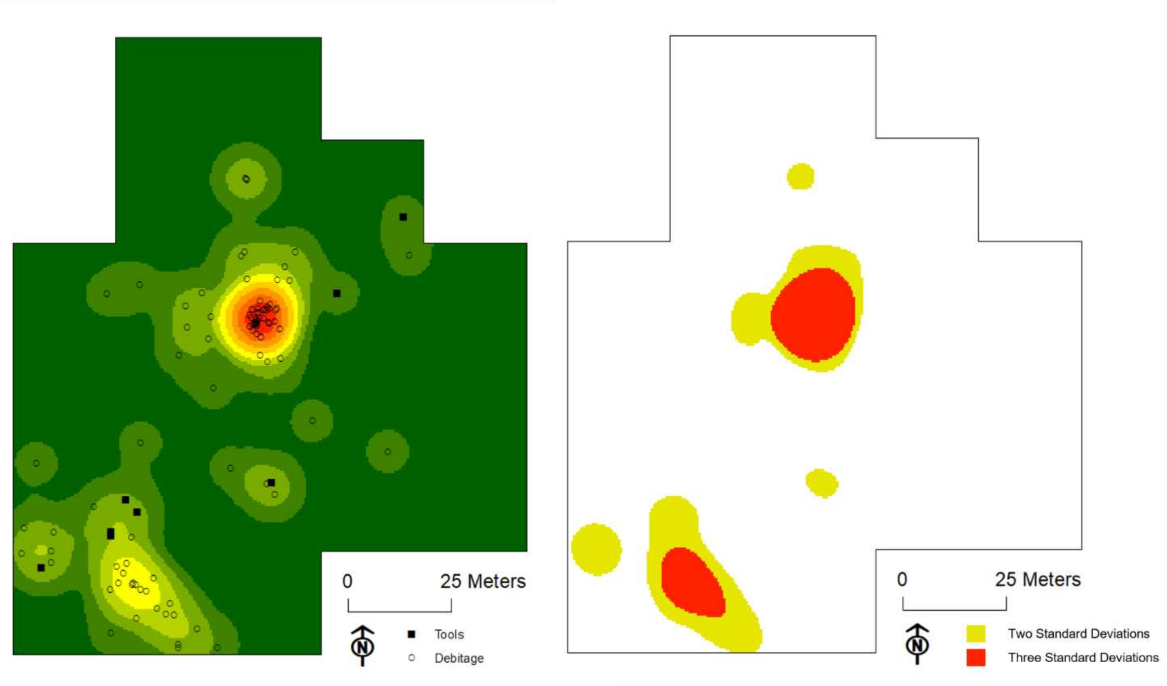


Figure 38. Results of the Kernel Density Estimation (KDE) analysis for the Twin Crater Lakes site. At left is the interpolated probabilistic density surface, output from the KDE tool in ArcGIS. At right is the reclassified KDE surface, showing standard deviations above the mean. High density areas with five or more artifacts, and exceeding two standard deviations above the mean, were used to define cluster boundaries.

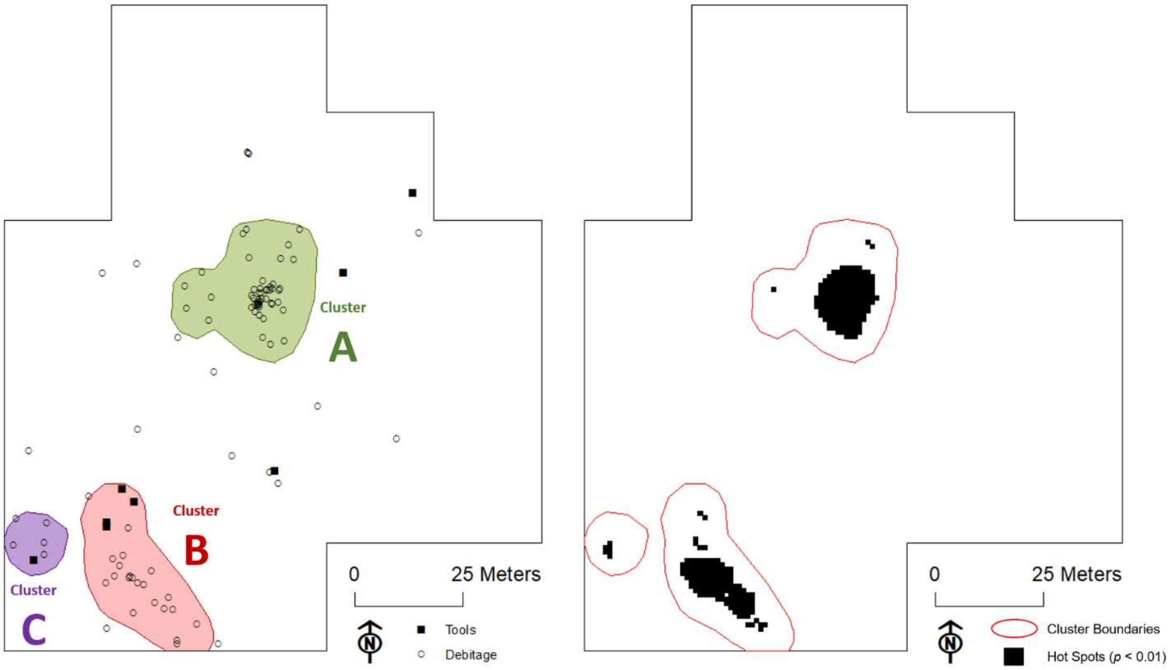


Figure 39. The three clusters, with five or more artifacts, defined from the surface artifact distribution at the Twin Crater Lakes site, shown at left. Validation of the clusters, using the Optimized Hot Spot Analysis tool, is shown at right. The cluster boundaries encompass all areas designated as hot spots at a confidence interval of $p < 0.01$.

Analysis of surface artifact distributions at the Twin Crater Lakes site identified three principle clusters among the surface assemblage (Figure 38, Figure 39). A total of five clusters were defined from the KDE analysis, however two of these clusters were comprised of fewer than five artifacts and were omitted. The defined cluster boundaries were then tested with the Optimized Hot Spot Analysis tool, and it was found that all statistically significant hot spots were encompassed within the identified cluster boundaries. The three clusters, designated A through C, were considered valid for analysis.

Table 12. Artifact composition of clusters identified at the Twin Crater Lakes site (5LR153/5LR237). The table shows the value for each category (N), as well as the cluster's percentile rank (%) when compared against sites in the WBLR sample.

	Artifacts		Tools		Tool Diversity (H)		Lithic Raw Material Diversity (H)	
Cluster	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
A	52	65	0	3	n/a	3	0	3
B	25	45	4	52	0.693	46	0.5	70
C	6	19	1	10	0	3	0	3

The next step of the analysis of the reuse of the Twin Crater Lakes site was examination of variation in artifact composition across the three clusters. Substantive differences exist in the quantity and character of the artifacts comprising each cluster, and these differences can be analyzed to determine if clusters represent distinct activity areas or non-contemporaneous occupations (Table 12). Cluster A is comprised of 52 debitage artifacts and no tools. All artifacts identified in Cluster A are likewise uniformly produced from CCS, and there is no lithic raw material diversity among the artifacts in the cluster. Cluster B, located approximately 40 meters away, consists of just 25 artifacts. Despite its smaller quantity of artifacts, however, four tools were found within the cluster and both quartzite and CCS artifacts are present among the cluster assemblage. Cluster C was the smallest of the clusters, with just six artifacts, and is located five meters from Cluster B. A single biface fragment manufactured from CCS was identified within Cluster C, and the remaining five artifacts were comprised of CCS debitage.

Variation among artifact composition in clusters points to variability in occupation intensity between these clusters, and suggests that surface context of the site may represent multiple discrete occupations. For example, though Cluster A has twice as many artifacts as Cluster B, there are no tools or lithic raw material diversity associated with the cluster. In contrast, Cluster B has evidence of moderate tool diversity and high lithic raw material diversity. If a site represents a single occupation we may expect to see spatially discrete clusters representing different activity areas, but across these clusters there should exist relatively homogenous tool and lithic raw material diversity. Particularly given a probable embedded lithic raw material procurement system, and material conservation strategy necessitated by a paucity of suitable local materials, substantive variation in lithic raw material diversity between clusters is strong evidence for non-contemporaneity of clusters (Bender 2015; Kvamme 1998). Variable lithic raw material types at a site, and corresponding tool diversity between clusters, is then likely representative of non-contemporaneous use and a differential occupation 'tempo' at the site (Simek 1989; Wandsnider 1992). In the Colorado Front Range for example, these same trends are apparent in Benedict's (1992) analysis of seasonal transhumance. Benedict (1992) notes that it was necessary to import suitable materials in easily transportable forms, and the routes by which people accessed high elevations influenced the material diversity of their toolkits. In the case of the clusters at the Twin Crater Lakes site, we may assume that substantive differences in lithic raw materials between clusters could represent different occupations of the site by hunter-gatherer groups who accessed the area via different routes (and thus acquired raw materials from different sources).

The identification of a tool refit at the site likewise has compelling implications for the contemporaneity of clusters. In contrast to other refit tools in the study area, such as fragments of 5LR131-90 which were found nearly a kilometer apart from one another, at the Twin Crater Lakes site the distal and proximal fragments of a large quartzite preform (5LR237/5LR153-2019-101 and 5LR237/5LR153-2019-102) were found within just 80 centimeters apart in Cluster B (Buckner 2019). Analysis of artifact refits and cross-mends is a powerful tool for examination of site formation processes, and can likewise be applied to evaluate contemporaneity of sites and intrasite clusters (Andrews et al. 2008; Schiffer 1987; Surovell et al. 2005). The identification of refits between discrete clusters, for example, is strong evidence of contemporaneity of those clusters (Andrews et al. 2008). Accordingly, the presence of refits only within a single cluster has been used to argue that discrete clusters represent different components (Surovell et al. 2005). Collectively, the presence of a refitting preform at the Twin Crater Lakes site, supported by the two Mount Albion points within one cluster, suggests that observed clusters are not contemporaneous and represent discrete occupations of the site.

The presence of discrete clusters of artifacts on the surface of the site, alongside substantive differences in the artifact composition of these clusters, indicates that variable occupational intensity occurred across space at the site. In the context of the timberline ecotone of the Medicine Bow Mountains, where lingering snow and alpine conditions limit individual occupations to the late summer months, this spatial and material signature is more consistent with reoccupation than a high-intensity single occupation. The discovery of a previously unknown Late Archaic component, in the form of a Pelican Lake projectile point, likewise reinforces the multicomponent nature of the site. The co-occurrence of both an Early Archaic and Late Archaic component at the site represents thousands of years of time, and the discovery of these diagnostics in different areas of the site suggest these components were structured in different areas of the site. Given this determination, where we see spatially discrete artifact concentrations which reflect characteristics of reoccupation and reuse, the Twin Crater Lakes site appears to represent a spatial palimpsest. The distribution of artifacts at the site suggests that reuse of the site was structured around the same terrain, a sheltered flat in close proximity to the lakes, but occupations were not necessarily directly superimposed. From this, there is evidence for Schlanger's (1992) first criteria for the development of persistent places, where optimal environmental conditions encourage reoccupation. The site's close proximity to the lakes, among the biggest in the study area, and the timberline ecotone may have been factors which served to encourage the preferential reoccupation of the site. From the 2019 investigations, there is no apparent evidence of the reuse of previously deposited artifactual material from the site or that reoccupation of existing features was the impetus of the reuse of the Twin Crater Lakes site. Given the dynamic visibility conditions of the timberline ecotone, and the exposure and concealment of surface artifacts from year-to-year, continued investigation of the site through high-resolution spatial mapping may clarify the nature of reuse of the Twin Crater Lakes area.

5LR233

First documented by Metcalf (1971a) during CSU's initial work in the WBLR watershed, site 5LR233 is located in the alpine ecozone at 3,455 meters above sea level. The site is associated with an unnamed tarn, and is situated in a high visibility setting just a hundred meters from the krummholz and modern timberline. Metcalf (1971a) and Morris et al.'s (1994) investigations of the site resulted in the collection of 33 artifacts, comprised of eight tools and 25 debitage artifacts. Among the extant assemblage is a large netherstone fragment, and Morris et al. (1994) assigned the site's function as a camp given the presence of ground stone. Ground stone occurs at just 16.6% of sites in the watershed, and analysis of the existing collection in Chapter 4 found that the site has a high tool diversity (1.73) which is greater than 96% of Rawah sites. Morris et al.'s (1994) analysis of the site identified evidence of only a single Late Archaic component at the site, and this analysis of the collection likewise identified only one temporal diagnostic which was typed as a Pelican Lake projectile point (5LR233-26). Despite the small assemblage size, and single known component, the site was selected for investigation due to the presence of ground stone and high tool diversity (Buckner 2019). Given that these assemblage characteristics were somewhat contradictory in relation to expectations for reoccupation, spatial analysis of the surface artifact distribution at the site was necessary to clarify if 5LR233 represents a reoccupied site or a high intensity single occupation.

The 2019 investigations at 5LR233 intensively sampled a 1.25 hectare area and identified 80 artifacts across the surface of the site. The large quantities of artifacts identified at the site in 2019 more than doubles the existing collection. Formal and informal tools included bifaces (n = 3) and an edge modified flake (n = 1). Debitage artifacts consisted of 76 flakes, which were produced from both CCS (85.5%) and quartzite (14.5%) materials. Tools, in contrast, were manufactured uniformly from CCS. High visibility conditions at the site allowed for identification and mapping of artifacts as small as 6.89 millimeters in length.

Analysis of surface artifact distributions across the surface of 5LR233 identified two primary clusters (Figure 41, Figure 42). The clusters, designated Cluster A and Cluster B, are situated 30 meters apart and are spatially separated by a low saddle. Both clusters are located in close proximity to the unnamed tarn at the northern extent of the sampled area, and a snow runoff stream at the southern extent. Cluster A is comprised of 19 artifacts, all of which are flake debitage. Cluster B is much larger, both spatially and in quantities of artifacts, and encompasses 54 artifacts. All four tools, identified at the site in 2019, are spatially associated with Cluster B.

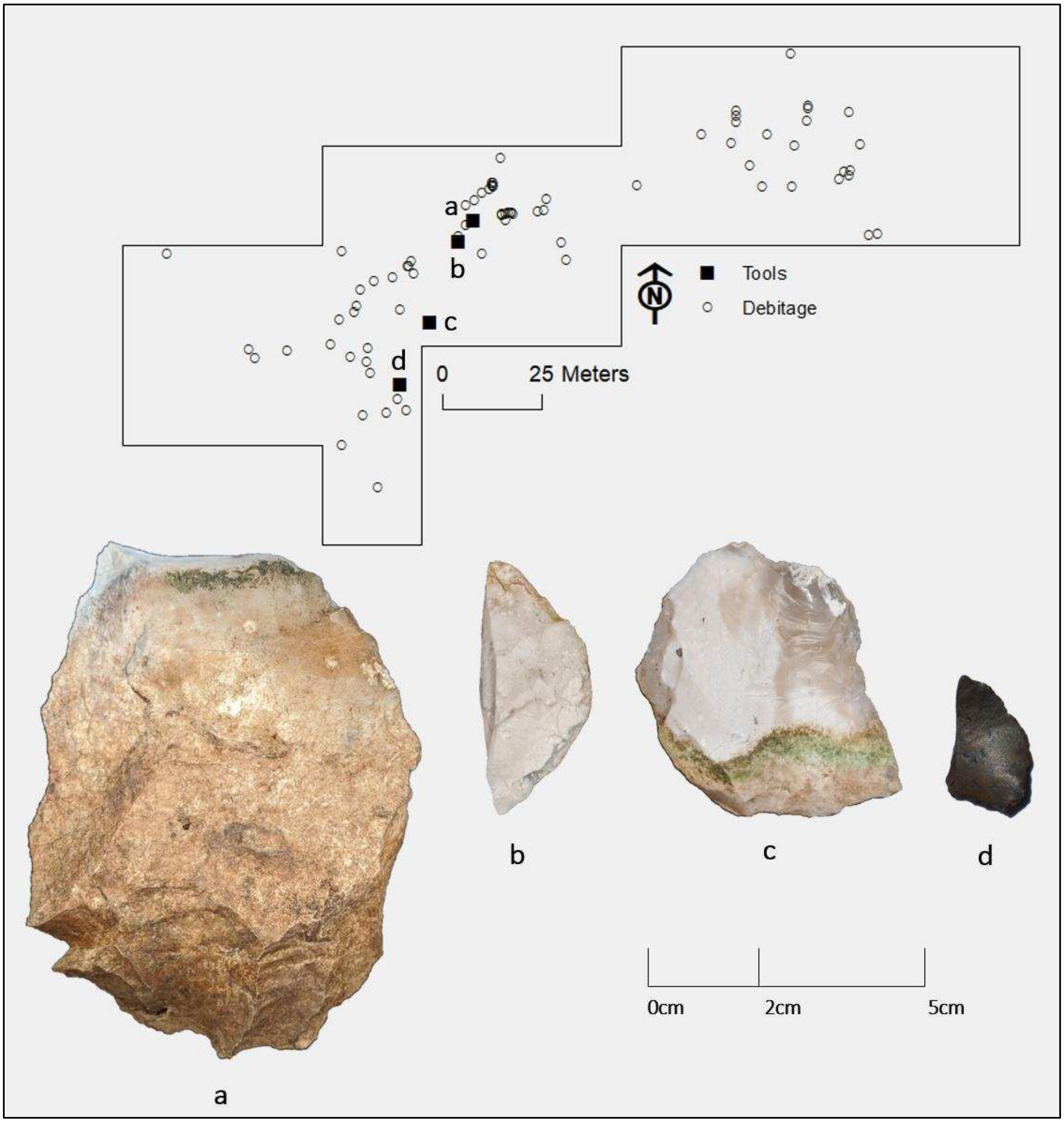


Figure 40. The results of intensive sampling at 5LR233. Identified tools include a large bifacial blank (**a**; 5LR233-2019-1), a late stage biface fragment (**b**; 5LR233-2019-4), an early stage biface fragment (**c**; 5LR233-2019-2), and an edge modified flake (**d**; 5LR233-2019-3).

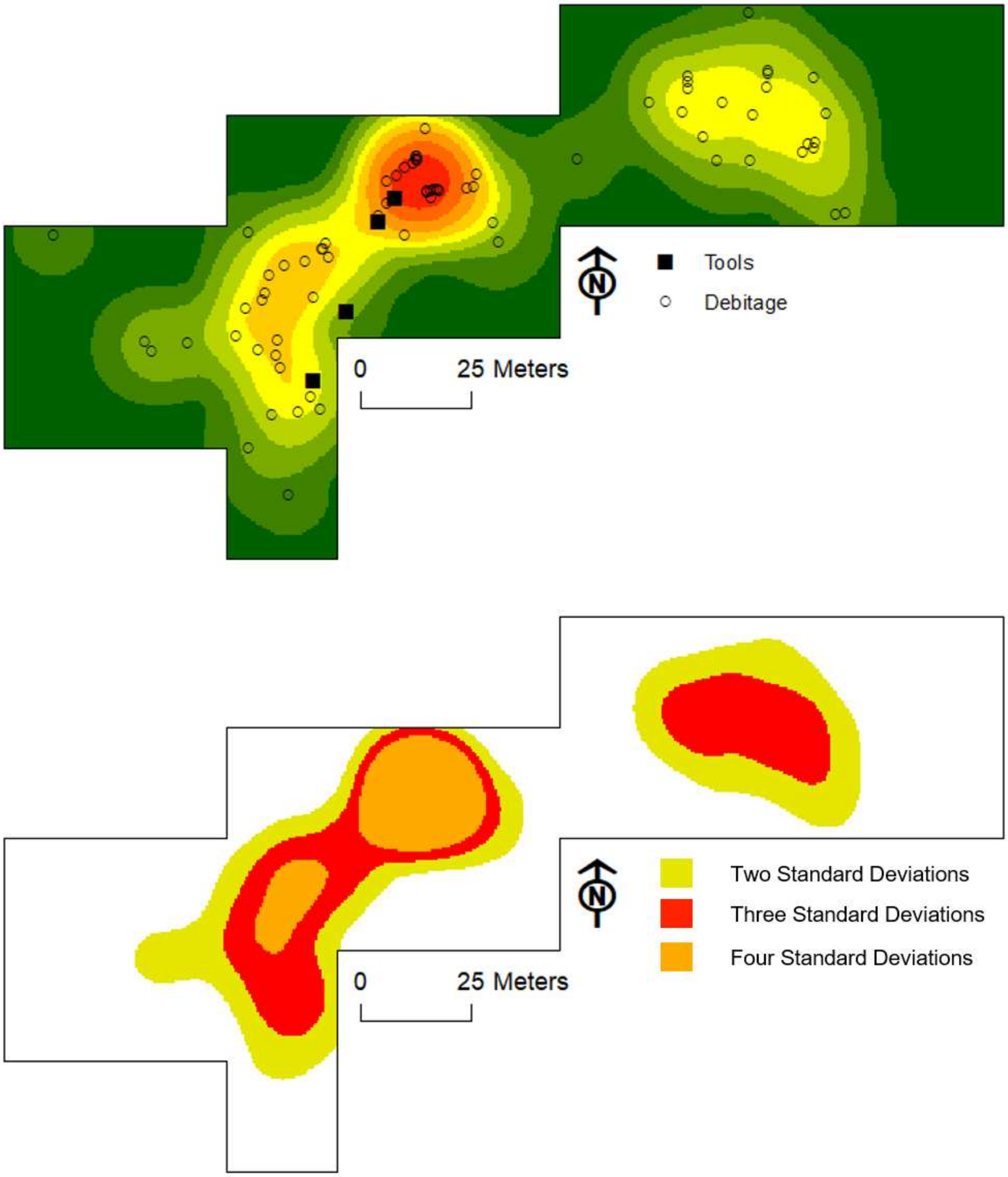


Figure 41. Results of the Kernel Density Estimation (KDE) analysis for 5LR233. Shown at top is the interpolated probabilistic density surface, output from the KDE tool in ArcGIS. At bottom is the reclassified KDE surface, showing standard deviations above the mean. High density areas with five or more artifacts, and exceeding two standard deviations above the mean, were used to define cluster boundaries.

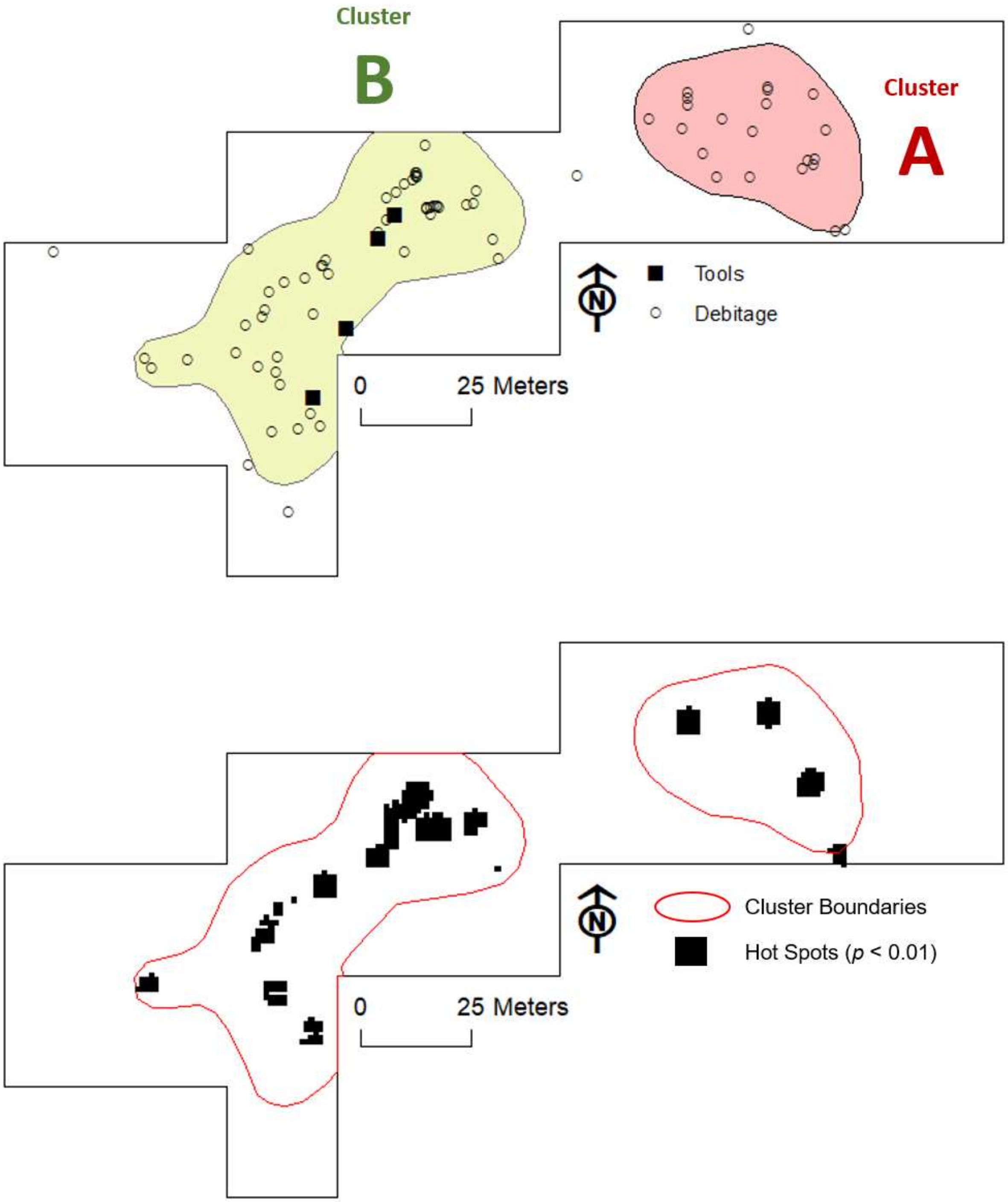


Figure 42. The two clusters, defined from the surface artifact distribution at 5LR233, shown at top. Validation of the clusters, using the Optimized Hot Spot Analysis tool, is shown at bottom. The cluster boundaries align with areas designated as hot spots at a confidence interval of $p < 0.01$.

Analysis of the artifact composition of Cluster A and Cluster B reveals a number of substantive differences between the clusters. For example, Cluster B is significantly larger that Cluster A, both in terms of quantity of artifacts and spatial extent. Despite this differential, Cluster A retains a substantially higher lithic raw material diversity. Though Cluster B contains nearly three times as many artifacts as Cluster A, the lithic raw material diversity of Cluster A is over 200% higher (Table 13). Given the closest distance between the clusters is just 30 meters, one would not expect to see such a high range of lithic raw material diversity if the clusters represented a single depositional episode. For example, even if artifacts had existed in the low saddle separating the clusters and had been removed by snowmelt runoff or tarn outflow, there is little reason to suspect that this formation process would result in such spatial polarization of raw material diversity. Instead, it is more probable that the clusters represent different depositional events, where occupying groups had visited the site at different stages of their annual round and had last procured lithic resources from different areas (Benedict 1992). Similar to the Twin Crater Lakes site described previously, there is no reason to expect that contemporaneous activity areas from a single occupation would be demarcated by different patterns of lithic raw material use. Reoccupation of the site, reflected by clusters associated with distinct occupations, is a likely explanation for these differences.

Table 13. Artifact composition of clusters identified at 5LR233. The table shows the value for each category (N), as well as the cluster's percentile rank (%) when compared against sites in the WBLR sample.

	Artifacts		Tools		Tool Diversity (H)		Lithic Raw Material Diversity (H)	
Cluster	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
A	19	32	0	3	0	3	0.681	97
B	54	65	4	52	0.562	24	0.216	45

Despite a lack of additional temporal diagnostics at 5LR233, substantive differences among the artifact and material composition of the identified clusters point to the multicomponent nature of the site. The discrete nature of these clusters, though separated by just 30 meters, indicates a spatial palimpsest depositional pattern occurred at the site. The site's proximity to the krummholz and timberline may have served as a draw to bands traveling through the area, as well as the availability of water resources. Though the site is located closely above the modern timberline, the occupation of the site may have been temporally associated with periods when the timberline advanced upslope and the site was sheltered from exposure by the krummholz. Generally, the spatial palimpsest patterns of artifact distributions points to occupations which were oriented around a common feature on the landscape (Bailey 2007). In the case of 5LR233, this is most likely the unnamed tarn which is located adjacent to the site. Both clusters are located on low rises, above the lakeshore to the north, and appear to take advantage of flat areas of topography in immediate proximity to the tarn. The structured orientation of the clusters in relation to the physical landscape provides some evidence for Schlanger's (1992) first criteria of persistent place formation, that optimal environmental conditions served to encourage preferential reuse of the site. Though there was no apparent evidence of the reuse of artifacts previously deposited at the site, or of site infrastructure, further investigation of the site may yield additional data in this regard.

Grassy Pass (5LR240)

The Grassy Pass site (5LR240) was first documented by Metcalf (1971a), and revisited periodically by Morris et al. (1994). The site is situated on the saddle of Grassy Pass, which is one of a few passable access points into the WBLR watershed. The site is located at an elevation of 3,415 meters above sea level, and is within the alpine ecozone. Prior to 2019, a total of 66 artifacts had been collected from the site. In Metcalf's (1971a) original field notes, he described two concentrations at the site. One concentration was reported on a small bench at the western extent of the pass, while a second concentration was documented at the crest of the pass. At the time of Metcalf's (1971a) recording, both concentrations were described as containing less than 10 artifacts each, however these observations could represent an interpretable site structure. Likewise, in contrast to the Twin Crater Lakes site and 5LR233, analysis of the extant assemblage from the Grassy Pass site identified at least three known components. These components include distinct Late Paleoindian, Early Archaic, and Late Archaic occupations, as reflected by temporally diagnostic projectile points, and the site offers a useful opportunity to evaluate the spatial structure and character of a site with definite repeat occupation over large time spans. Similar to 5LR233, this site was also one of four in the study area with ground stone present in the assemblage, another indicator of the use intensity of the site which can be evaluated to inform understandings of reoccupation.

During the 2019 investigations at Grassy Pass, a total of 0.87 hectares was sampled and intensively surveyed. In this area, 61 debitage artifacts and six tools were identified and mapped across the site surface. Many of the artifacts were found concentrated on a small bench located at the western extent of the pass crest. Tools found in this area included a proximal fragment of a point preform, a netherstone fragment, the base of an Early Archaic Mount Albion point, a distal fragment of a late stage biface, and the distal fragment of an unassigned Archaic projectile point. Outside of the western area of the site was a complete end scraper, which was identified just below the crest of the pass (Figure 43). Across the site, material types were comprised of CCS (88%), quartzite (10.4%), and sandstone (1.6%). High ground visibility likewise enabled identification and mapping of artifacts as small as 7.25 millimeters in length.

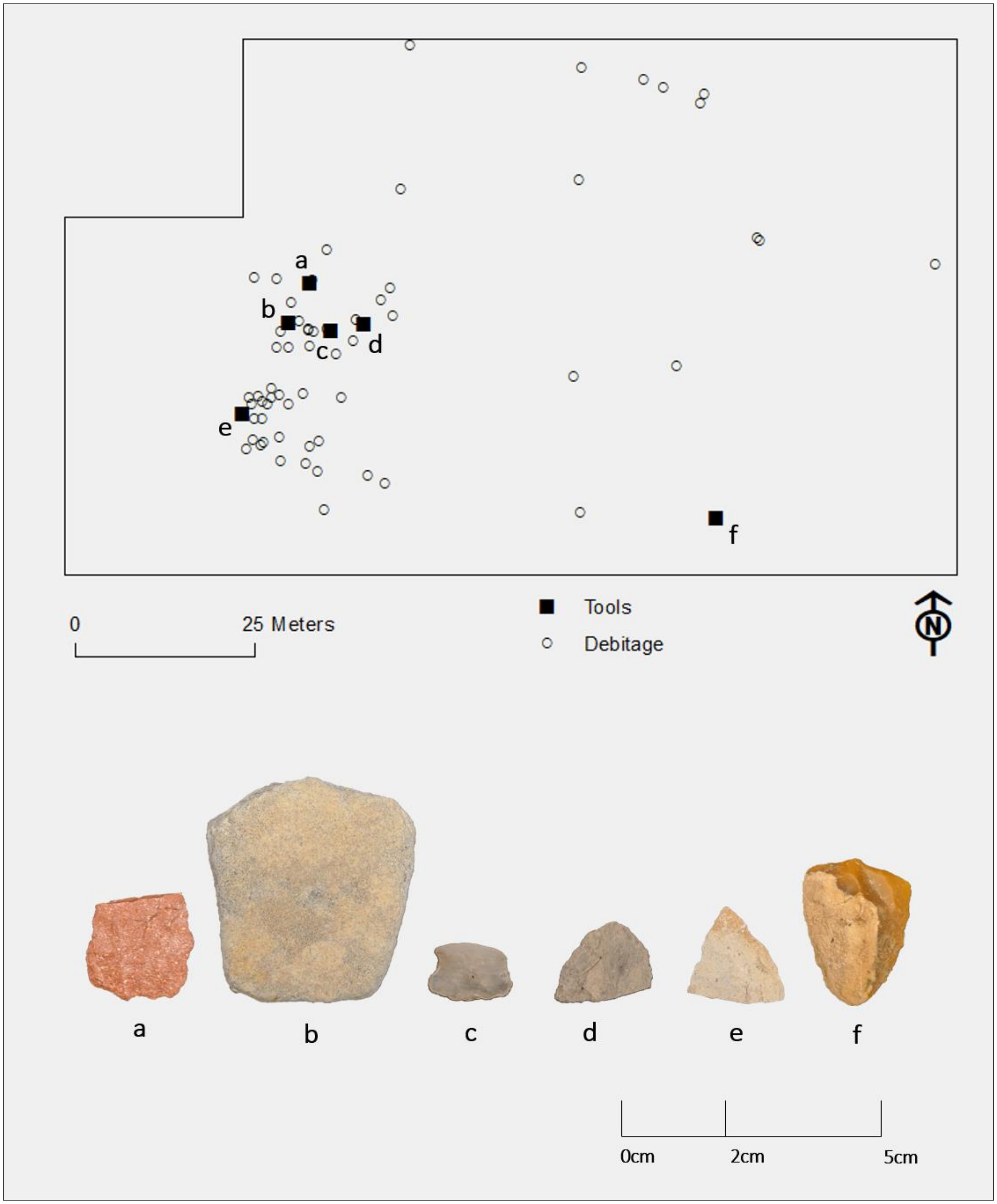


Figure 43. The results of intensive sampling at the Grassy Pass site (5LR240). Identified tools include a preform (**a**; 5LR240-2019-28), a netherstone fragment (**b**; 5LR240-2019-29), an Archaic Mount Albion projectile point base (**c**; 5LR240-2019-27), a distal late stage biface fragment (**d**; 5LR240-2019-26), a distal projectile point fragment (**e**; 5LR240-2019-30), and an end scraper (**f**; 5LR240-2019-25).

Analysis of the surface distribution of artifacts at 5LR240 identified only a single cluster at the site. Though Metcalf (1971a) reported at least two concentrations at the site, his observations were based on small quantities of materials. The results of the spatial analysis of the artifacts mapped in 2019, following the application of an intensive sampling strategy, identified only a single cluster. The cluster, designated Cluster A, sits in the western area of the pass on a small elevated bench. It is likely that Cluster A represents the concentration which Metcalf (1971a) also described as existing in the area. Metcalf's (1971a) second concentration may be associated with various small concentrations of flakes observed in the north central area of the site, however these did not meet the criteria to be designated as a distinct cluster (Figure 44).

Cluster A is comprised of 51 artifacts, including five tools. The observed tools represent multiple different classes and the cluster has a tool diversity in the 79th percentile for the WBLR watershed. The cluster likewise retains a high lithic raw material diversity in the 61st percentile for the study area. The presence of large numbers of debitage and tools concentrated in an approximate 35 meter by 25 meter concentration is indicative of the intensive use of this area of the site. Likewise, despite its small size, the cluster's artifact composition is above average when compared to all *sites* in the WBLR study area for quantity of artifacts, quantity of tools, tool diversity, and lithic raw material diversity. Together, these high values concentrated in a single intrasite area are indicative of the intensive and concentrated occupation of the Grassy Pass site.

Table 14. Artifact composition of the lone cluster identified at 5LR240. The table shows the value for each category (N), as well as the cluster's percentile rank (%) when compared against sites in the WBLR sample.

	Artifacts		Tools		Tool Diversity (H)		Lithic Raw Material Diversity (H)	
Cluster	*N*	%	*N*	%	*N*	%	*N*	%
A	51	65	5	61	1.332	79	0.456	61

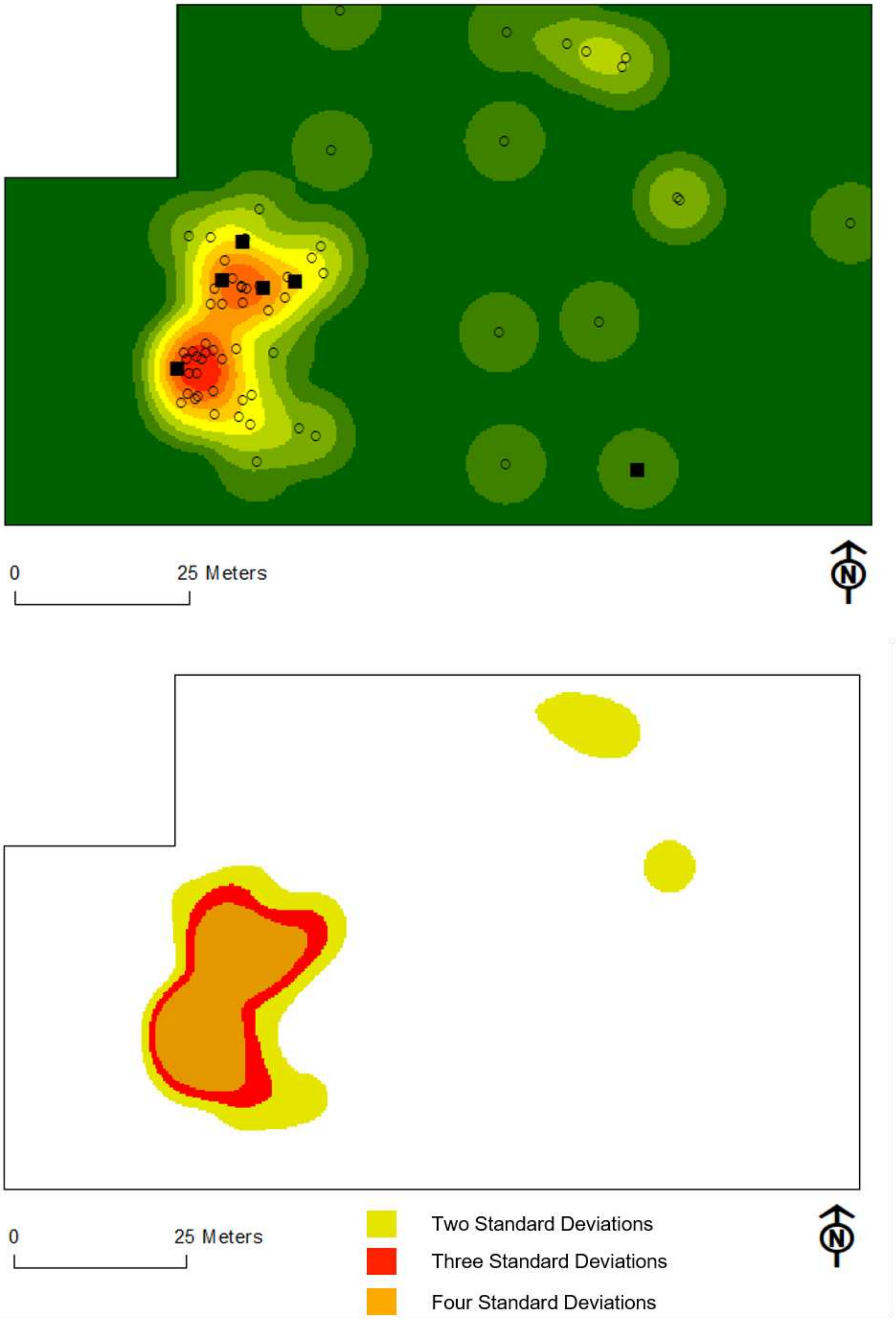


Figure 44. Results of the Kernel Density Estimation (KDE) analysis for 5LR240. Shown at top is the interpolated probabilistic density surface, output from the KDE tool in ArcGIS. At bottom is the reclassified KDE surface, showing standard deviations above the mean. High density areas with five or more artifacts, and exceeding two standard deviations above the mean, were used to define cluster boundaries.

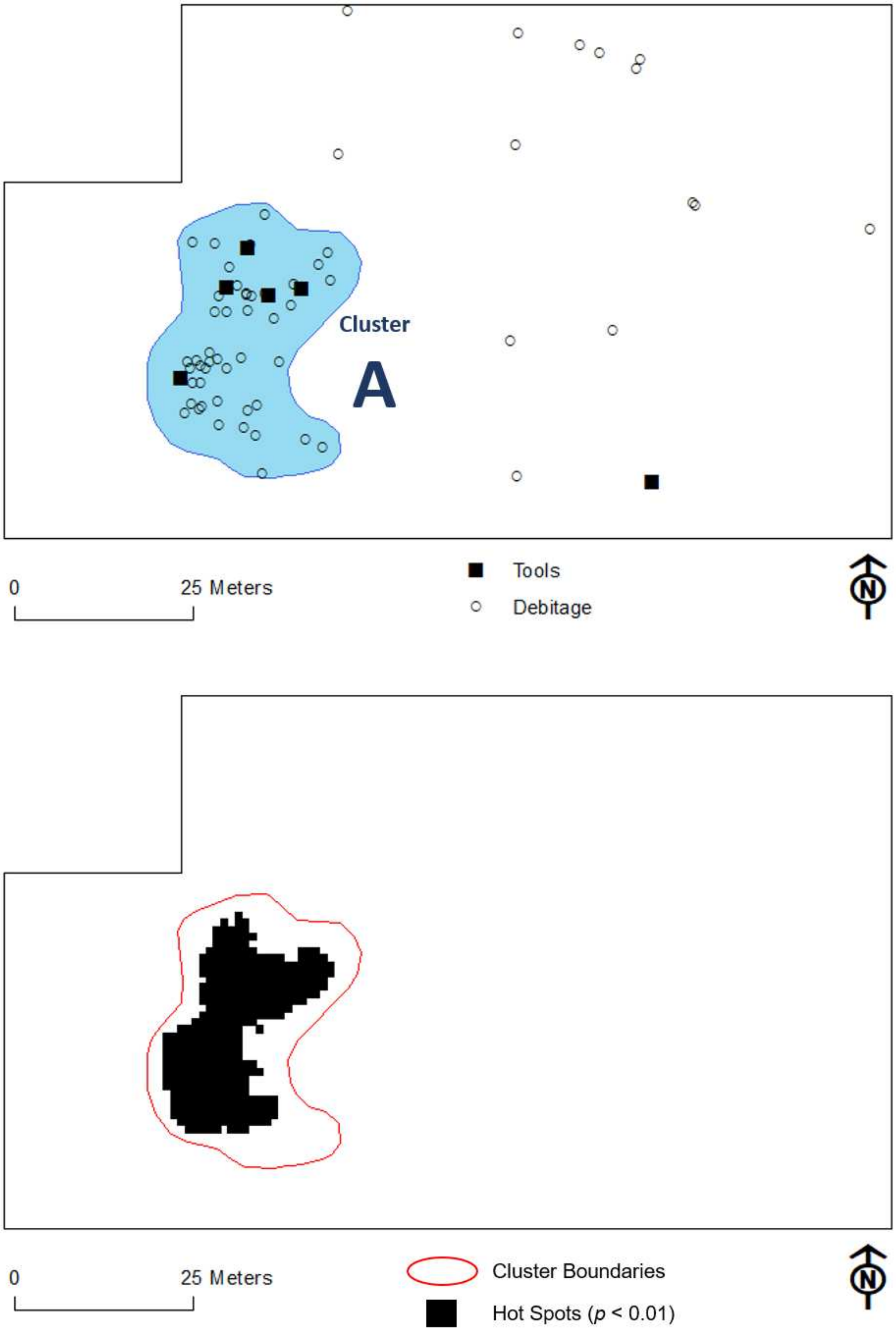


Figure 45. The single cluster defined from the surface artifact distribution at 5LR240, shown at top. Validation of the cluster, using the Optimized Hot Spot Analysis tool, is shown at bottom. The cluster boundary encompasses all areas designated as hot spots at a confidence interval of p < 0.01.

The highly concentrated but diverse nature of the artifact composition of Cluster A is strong evidence for the site's status as a cumulative palimpsest. The nature and topography of the pass, which acts as a bottlenecked travel corridor, limits settlement of the area to a few suitable places. The location of Cluster A, on a dry and flat bench above the pass, was one such area which offered suitable conditions for temporary settlement. Given the necessity of moving through the pass to access the WBLR watershed from the north, the pass represents one of the areas of the watershed which was most likely to be repeatedly encountered by bands entering and exiting the area. The repeat occupation of a suitable area on the pass (Cluster A), led to the superimposition of artifacts over deposits form previous occupations, creating a cumulative palimpsest.

Discussion: Implications of Site Structure for Reoccupation

Spatial analysis of artifact distributions at sites with high evidence of reuse appears to indicate that reoccupation signatures are identifiable on the surface of these sites. The surface site structure of both the Twin Crater Lakes site (5LR153/5LR237) and 5LR233 show signs of non-contemporaneous depositional periods representing a spatial palimpsest. Substantive differences in the artifact composition of discrete clusters at these sites is more consistent with reoccupation rather than long-duration single occupation, particularly in the specific context of high-elevation conditions. These findings were supported at the Twin Crater Lakes site, where definitive evidence of a Late Archaic component was identified in 2019, which validated the interpretation of the site as a reoccupied site and supported Morris et al.'s (1994) typological determination of site components. The Grassy Pass site (5LR240), though only a single cluster was identified, likewise shows evidence of reoccupation that is supported by temporal diagnostics in the existing collection. The lone cluster at Grassy Pass is tightly concentrated but it concurrently reflects a higher tool and lithic raw material diversity than 61% to 79% of sites in the WBLR watershed. Though this interpretation is supported by the identification of at least three known components from existing Morris et al. (1994) and Metcalf (1971a) collections, the spatial context alone is compelling evidence that the site represents a cumulative palimpsest deposit. The topography of the pass, as well as the nature of its use, focused occupation of the site into one constrained area which structured the use of the place (Schlanger 1992).

Though analysis of surface contexts to identify reoccupied sites is not a replacement for excavation or absolute dating methods, these results provide strong evidence to suggest that reoccupied sites can be reliably distinguished from single component sites in high elevation contexts. In this way, these methods are a powerful tool for archaeologists working at high elevations, given the logistical and regulatory difficulties of conducting excavations in these conditions. Such determinations are likely to be less practical at lower elevations, where long-term seasonal or year-round occupations are possible, however the highly constrained seasonal nature of alpine and subalpine occupations allows for easier discrimination of reoccupation at these sites (Benedict 1992). To further evaluate the spatial and site structure considerations for persistent reoccupation of these places, it is then useful to compare the WBLR watershed sample against excavated sites from similar high elevation contexts. Though excavations at high elevations are rare, several decades of research in the Indian Peaks Wilderness has resulted in a useful dataset for comparison. Additionally, Morris and Marcotte's (1976) work on the Joe Wright Reservoir site (5LR450) offers an example of an excavated site nearby to the study area. To compare the surface patterns identified in the Rawah Wilderness in 2019 against excavated sites with confirmed evidence of reoccupation in similar conditions, a brief discussion of these patterns is useful for interpretation of the WBLR watershed sample.

Benedict's (1974, 1985, 1989) and Pitblado's (2000) work at the Caribou Lake site (5GN22), Benedict's (2000) excavation of the Fourth of July Mine site (5BL153), and Morris and Marcotte's (1976) excavation at 5LR450 are examples of excavated reoccupied sites in high elevation contexts. Each of these sites is located in the alpine or subalpine ecozone, and many of them are associated with the timberline ecotone, and are situated in similar environmental contexts to sites in the study area. Collectively, comparative analysis of the surface and subsurface data detailed in these studies is necessary for the interpretation of the Rawah localities investigated in 2019.

Similarly, Morris and Marcotte (1976) identified at least five spatially associated localities at 5LR450, which were variously dated to the Late Archaic and Late Prehistoric. Later surface mapping by the Center for Mountain and Plains Archaeology, several decades after the expansion of the reservoir, likewise identified a surface context comprised of disparate artifact scatters (Meeker et al. 2016). The site displays a clear pattern of variable reoccupation intensity reflected by these discrete clusters, and they have significant utility for interpretation of patterns seen among the WBLR sites. Similar depositional patterns were observed at the Twin Crater Lakes site and 5LR233, with clearly defined clusters apparent on the surface. At 5LR450, surface artifact concentrations of lithic debris were used to identify distinct loci of the site and target excavations (Morris and Marcotte 1976). Localities were separated from the next nearest locality by distances ranging from approximately 20 meters to 100 meters, within the range of clusters identified from the 2019 investigations. The spatial structure of the localities identified by Morris and Marcotte's (1976) suggests they are analogous to the clusters identified in this study. Excavations and testing at Locality One (surface n = 39) and Locality Two (surface n = 42) resulted in the recovery of 1,054 artifacts and 133 artifacts respectively (Morris and Marcotte

1976). Excavation of all localities likewise resulted in identification of substantive discrepancies in raw material type composition across the site. These discrepancies, where differential ratios of quartzites and chalcedonic cherts were evaluated between clusters, were hypothesized to represent evidence of reoccupation and is similar to the interpretation applied to the spatial datasets analyzed in this study (Morris and Marcotte 1976:24). These findings, from excavation of the spatial palimpsest at 5LR450, confirmed many of the same expectations applied to the sites mapped in 2019. Namely, subsurface deposits yielded definitive evidence of reoccupation of the site which were associated with substantive differences in raw material type composition for each locality (cluster).

Investigations at the Fourth of July Mine site (5BL153), located in the Colorado Front Range, yielded similar results. Here, Benedict (2000) excavated a series of thermal features eroding from a cut hiking trail. Given the significant quantity of features at the site, Benedict (2000) sought to determine if the site represented a long-term base camp. Analysis of the spatial distribution of artifacts, however, led Benedict (2000:182) to conclude that the site "was visited repeatedly […] over the course of many millennia" and was preferentially reoccupied due to its association with the timberline ecotone and ease of access to game drive sites. A high temporal diversity of projectile points, dispersed over the surface of the site, likewise supported this assertion. Though differences in sampling strategies make direct comparison difficult, and additional surface mapping at the site is required, Benedict's (2000) findings at 5BL153 exhibit a number of similarities and contrasts with the Rawah Wilderness sites. Notably, Benedict (2000:182) describes the surface record as consisting of thin lithic scatters with a stark "lack of stratigraphic or artifactual evidence for repeated use". Benedict (2000:162) described this surface context as "a patchwork of overlapping prehistoric campsites", a distribution consistent with a spatial palimpsest depositional pattern. Given that projectile point typologies and radiocarbon dates from the site are strong evidence for the long-term episodic reuse of the site, this apparent contradiction is worthy of exploration. In fact, the record of 5BL153 is fairly consistent with trends seen on the surface of the Rawah Wilderness sites investigated in 2019. With the notable exception of the large quantities of features eroding from 5BL153, many of the Rawah sites exhibit similar patterns of temporally unassociated single-occupations structured around a common landscape feature. This spatial palimpsest pattern, as mentioned previously, is seen at both the Twin Crater Lakes site and 5LR233. Drawing from Schlanger's (1992) framework, the lack of evidence for reused cultural facilities at the Fourth of July Valley Mine site is indicative of the preferential reoccupation of the site for its optimal environmental conditions (shelter of timberline ecotone and ease of access to alpine resources). In the case of the Rawah assemblages, a site occupying the same niche as 5BL153 could be expected to reflect a very similar surface context. It is likely that the Twin Crater Lakes site and 5LR233 both fill this same role, as spatial palimpsests reflecting reoccupation structured around reuse of an environmentally strategic place. For these reasons, the surface context at 5BL153 is aligned with many of the same expectations for similar sites in the Rawah Wilderness. Just as Benedict (2000:160) determined that the site constituted a "patchwork" of reoccupation rather than a single long-duration base camp, the analysis of surface artifact distributions at Twin Crater Lakes site and 5LR233 indicates they represent a similar pattern of repeat reuse rather than high intensity ephemeral occupation.

The Caribou Lake site (5GA22), in contrast, provides an opportunity to examine a mixed reoccupied context comprised of both spatial and cumulative palimpsest deposits (Benedict 1974, 1985; Pitblado 2000). At 5GA22, three primary excavation areas produced evidence of six variously overlapping depositional units associated with Protohistoric, Late Prehistoric, Archaic, and Paleoindian components (Benedict 1985). The setting of the site, adjacent to a lake and situated at 3,400 meters above sea level, closely mirrors the Twin Crater Lake site and 5LR233. The archaeological context of the surface archaeology at the site is likewise consistent with the findings at these sites. Benedict (1985:108) observed "several concentrations" of artifacts associated with the shore of the lake. Excavations of these concentrations, designated Area A through Area C, revealed that these clusters represented overlapping periods of occupation. Though Benedict (1985:108) was ultimately able to define six depositional units, the "thoroughly intermixed" context of multiple components at the site was a persistent challenge. The spatially discrete but overlapping nature of the repeat occupation of the Caribou Lake site reflects both the spatial and cumulative nature of the palimpsest deposits at the site. In this way, data from the site is useful for interpreting both the spatial palimpsest context identified at the Twin Crater Lakes site and 5LR233, as well as the cumulative palimpsest deposit present on the surface of the Grassy Pass site. In Area A, for example, Benedict (1985) observed distinct debitage concentrations on both the 'lower' and 'upper' surface of occupation. As frost-sorting processes resulted in some vertical post-depositional disturbances to the site, Benedict (1985) relied partially on differences in raw material composition across these concentrations to differentiate the different occupational episodes of Area A. Similarly to the Grassy Pass site, the high lithic raw material diversity concentrated on the surface of the site may be a result of the erosion of subsurface deposits such as those observed by Benedict (1985). Along with the overlapping nature of the lower and upper occupation surfaces, Area A of 5GA22 is an excellent example of a cumulative palimpsest alongside Grassy Pass. Benedict (1985) attributes the successive occupation of Caribou Lake to its viewshed, proximity to the timberline ecotone, access to alpine game drives, and optimal camping conditions, and the overlapped occupation of Grassy Pass was likely due to similar constraining circumstances related to its use as a travel corridor and access point to the greater WBLR valley.

The results of the analysis of surface contexts of likely reoccupied sites in the Rawah Wilderness yielded three principal conclusions. First, reoccupation can be reliably recognized from surface contexts at high elevations. Particularly given the seasonally limited nature of occupations in alpine climates, there is high potential for archaeologists to successfully identify the signatures of these ephemeral seasonal occupations. Second, reoccupation of these sites is reflected in site structure by spatial and cumulative palimpsest deposits at these sites, and these deposits can be analyzed in relation to their larger context to identify how reuse of place was structured at these sites. And third, variability in occupation intensity across site surfaces and between the artifact composition of clusters is a powerful tool for analysis of reoccupation intensity and episodic reuse of these locales. Analysis of the composition of these surface deposits, though limited by visibility considerations, can have significant utility for identification of contrasts indicating reoccupation when compared against a larger landscape sample. When available, such as for this study, cross-comparison of the artifact composition of clusters against other contexts is a powerful tool for recognizing characteristics of reoccupation even when temporal diagnostics are not present. Though these findings are not a replacement for subsurface investigation, archaeologists investigating sites in high elevation contexts should apply these considerations when evaluating the significance and data potential of these sites. Though time-averaging of these contexts makes analysis of surface contexts challenging, breaking surface artifact distributions into cross-comparable intrasite units of analysis is a time efficient and effective means of recognizing reoccupation in surface contexts.

CHAPTER 7 – CONCLUSIONS AND FUTURE DIRECTIONS

The results of this study reinforce the persistent nature of hunter-gatherers' long-term use of high elevation landscapes in the Southern Rocky Mountains. Analysis of assemblage composition, site distributions over landscapes, and surface palimpsests demonstrate that measurable patterns of reuse exist within the archaeological record of the Medicine Bow Mountains. These patterns, representing the episodic reoccupation and persistent use of place, have significant implications for understanding landscape use systems in the broader context of northern Colorado prehistory. As a foundation for continued study of the archaeology of the Rawah Wilderness, these results likewise highlight the potential for analysis of the Medicine Bow Mountains to contribute to broader understandings of high elevation landscape use in the Southern Rocky Mountains, as well as to studies of the connectivity or isolation of land use systems across northern Colorado's alpine and subalpine environments.

The conclusions of this analysis also demonstrate the validity of the theoretical expectations for persistent reoccupation discussed in Chapter 3. Though the high elevation archaeological record in the Southern Rocky Mountains can be highly variable, and is innately distinguished from lower elevations by the challenging conditions found in these environs, this thesis demonstrated that persistent places can be recognized in these contexts using these well established expectations for assemblage composition, landscape distribution, and site structure. The Clarke Effect for example, which was developed in the context of a sedentary settlement system with indefinite occupations, was shown to apply equally well to the episodic nature of mountain occupations (Schiffer 1975, 1987). The Clarke Effect was used to derive expectations for the assemblage composition of persistent places at high elevations and the study demonstrated that the “statistical tendency” outlined by Schiffer (1987:55) was present in these high elevation assemblages when evaluated against other criteria for preferential reoccupation. The thesis likewise demonstrated that the “shifts in […] utility” and accumulated use of place through time represented by this tendency were a critical aspect of the high elevation surface record in the Southern Rocky Mountains (Binford 1982:21; Shiner 2009). Expectations derived for landscape-scale distributions and site structure, using Schlanger’s (1992) persistent place criteria, palimpsest theory from Bailey (2007), and others, were also shown to be useful for generating hypotheses for the high elevation record.

In Chapter 4, analysis of existing site collections identified a range of reoccupation intensity for sites within the study area. By testing expectations for reoccupation and assemblage composition, the analysis identified sites with evidence of high reuse. Though diagnostic temporal indicators were withheld from the analysis as a control, known multicomponent sites were successfully aligned with assemblages pinpointed as exhibiting evidence of reoccupation. These sites, identified as exhibiting evidence of high reuse, were likewise found to be consistent with Morris et al.’s (1994) own determinations of sites which likely represented multiple components. Analysis of assemblage characteristics likewise identified patterns of reuse which can inform broader understandings of high elevation landscape use in the Medicine Bow Mountains. High degrees of variability among the assemblage composition of reoccupied sites, for example, represent divergent patterns of landscape use through time. While the assemblage characteristics of moderate reuse and low reuse sites were largely consistent, the variability of high reuse assemblages suggests variable systems of transhumance, settlement, and site function are present in the archaeological record of the Rawah Wilderness. Clarification of these systems will be critical for not only improving understanding of the indigenous use of the Medicine Bow Mountains, but also for the Colorado Front Range and the larger northern Colorado region.

Chapter 5 explored the landscape and environmental implications of these results. By creating spatiotemporal models of the distribution of high reuse, moderate reuse, and low reuse sites, the analysis considered the conditions which drive reoccupation and persistent place formation. Through analysis of the response of site suitability to a set of environmental variables, defined from the literature and a priori expectations, the study was undertaken to identify if reoccupation was environmentally driven, or dependent on other conditions. The results of the study support Schlanger's (1992:97) first criterion for persistent place formation, that the "unique qualities" of certain parts of the landscape attracted reuse, though it similarly exposed a high degree of variability in high elevation landscape use patterns. For example, though suitability for high reuse sites was associated with high elevations and proximity to ecotone boundaries, reoccupation was not explicitly associated with an environmental niche. The importance of the timberline ecotone in the Colorado Front Range, however, is added evidence to suggest that similar landscape use trends are occurred in the Medicine Bow Mountains. The timberline ecotone offered protection from harsh alpine conditions while allowing for expedient access to alpine and subalpine resources, and these optimal conditions attracted repeat occupation through time (Benedict 1985, 1990, 1992, 2000; Morris et al. 1994). The frequent occurrence of high reuse sites in association with the timberline ecotone suggest it acted as a destination for groups accessing the WBLR watershed from lower elevations. The presence of high reuse sites on alpine passes and at river confluences, however, demonstrates that persistent reoccupation was not limited to the timberline ecotone. Rather, though the study confirms that the timberline ecotone was an important component of landscape use systems in the Medicine

Bow Mountains, the persistent use of place at high elevations was an amalgamation of many complex social and environmental dynamics.

Following the identification of reoccupied sites from existing collections, and analysis of their distribution over the landscape, the final analytical chapter addressed the question of reoccupation at the site scale. By exploring the physical characteristics of reoccupation, as reflected in the surface distribution of artifacts at sites, Chapter 6 confirmed that the archaeological record of the Medicine Bow Mountains represents a complex palimpsest of overlaying occupation episodes. Through high resolution mapping of artifact distributions at sites, the study undertook a sophisticated spatial analysis of these surface contexts to identify evidence of the spatial character of reoccupation. The results of the study demonstrate that cumulative and spatial palimpsest depositional patterns are observable on the surface of sites, and that analysis of these patterns can be used to evaluate reoccupation intensity. Despite the time averaging of these surface contexts, the study employed theoretical expectations for the artifact composition of distinct clusters to isolate variability in occupation intensity in the spatial structure of each site. The analysis identified substantive patterns in the composition of surface clusters on the surface sites, and variation in the artifact composition of these clusters was used to identify contrasts which were not characteristic of short-term ephemeral occupation. Similarly, given the inherent limitations of occupation in the high elevations of the alpine and subalpine ecozone, many of these patterns are more consistent with reoccupation than even long-duration single occupation. The study likewise validated the results of the analysis of assemblage compositions in Chapter 4. The Twin Crater Lake site (5LR153 / 5LR237), despite typological evidence of only an Early Archaic Mount Albion component, was classified as a probable reoccupied site with high evidence of reuse. When visited and mapped in the field, for analysis of its spatial character in Chapter 6, the discovery of a Late Archaic component confirmed the status of the Twin Crater Lakes site as a reoccupied locale. Though no substitute for subsurface investigations, the study reiterates the power of surface analyses for reconstructing the long-term use of a site.

These results have broad implications for approaches to high elevation archaeology in the Medicine Bow Mountains. First, it reinforces the inherent contradiction of the wilderness concept and the importance of considering these landscapes in larger regional analyses. As described by Cronon (1995), Anderson (2005:4), and others, the diverse indigenous uses of ostensibly uninhabited wilderness left an “indelible imprint” on the landscape. Generally, a lack of compliance surveys and a systematic perception of wilderness areas as ‘untrammeled by man’ pose serious obstacles to improved understanding of the archaeology of these high elevations (Adams et al. 2014; Blecha 2015). Alongside Benedict (1981, 1985, 1990, 1992, 2000) and other’s work in the Indian Peaks Wilderness, this study follows the pioneering work of Metcalf (1971a) and Morris et al. (1994) in recognizing the rich archaeological record and dynamic cultural landscape represented by the Rawah Wilderness. Second, the study reinforces the need for comparative analyses between the Medicine Bow Mountains and the Colorado Front Range. Though there are many similarities in the use of both ranges, there are significant contrasts in both the character of the archaeological record and research intensity. Clarification of these contrasts, such as the absence of alpine game drives and pottery in the Medicine Bow Mountains, and limited utilization of ground stone technology, has a significant potential to contribute to broader understandings of larger cultural systems in northern Colorado prehistory.

This project has additional implications for the management approaches to archaeological resources, compliance archaeology, and evaluation of the significance of hunter-gatherer archaeological sites for inclusion on the National Register of Historic Places (NRHP). First, in the management of archaeological sites in remote backcountry settings, the methods described here are a useful tool for identifying sites which are likely to represent persistent places. This is particularly critical for federal land management agencies’ allocation of resources for the study and preservation of sites, particularly as agency resources are increasingly strained by wildfire threats and other high severity climate change impacts. At the time of writing for example, the Cameron Peak Fire became the largest recorded wildfire in state history and burned thousands of acres within and adjacent to the study area. With an improved understanding of which places on the landscape may represent significant reoccupied sites, the USDA-FS could respond to the Cameron Peak Fire and similar wildfires by identifying areas where these persistent places may occur and by documenting them before they are adversely impacted by post-fire erosion and other threats. This research has similar implications for the cultural resource management industry and its standards for evaluating NRHP eligibility. It is clear from the research conducted here that cultural resource management archaeologists must consider more variables when making NRHP eligibility determinations from surface and/or limited subsurface contexts. For example, though a site may be lacking projectile points or other diagnostic artifacts due to illicit surface collection or other factors, archaeologists should consider other aspects of the surface context of sites, such as raw material and tool functional diversity, to identify evidence of their preferential use through time. Generally, cultural resource management archaeologists should also place greater emphasis on reoccupation when assigning eligibility. Persistent places, by their definition, reflect the preferential use of a place over long temporal scales and reflect a clear historic significance under the criteria of the NRHP. Greater emphasis in cultural resource management on identifying these places, and by utilizing a broader suite of variables for identifying them through analysis of the surface assemblage composition of sites, will preserve critical sites for future research.

Although the study was a success, and clarified many questions surrounding the reuse of mountain landscapes in the Medicine Bow Mountains, there were a number of limitations which future studies may resolve. First, the extent and quality of the Rawah Wilderness sample is somewhat unclear. Though Metcalf (1971a) and Morris et al. (1994) left an invaluable dataset for analysis of the Rawah Wilderness, no formal survey data is available. Similarly, though Morris et al. (1994) implemented a 100% surface collection strategy which yielded a substantial sample for analysis, it is unclear how frequently each site was revisited. These issues could be resolved with the longitudinal collection and mapping of these sites, such as is underway for the Carey Lake site (LaBelle and Meyer 2017; Meyer 2019b; Meyer and LaBelle 2017). Second, there are numerous questions surrounding lithic raw materials in the Rawah assemblages. Czubernat's (2019) minimum analytical nodule analysis, for example, identified substantial variability among lithic raw material types which appear to represent the same sources. Clarifying the range of variability and sourcing of lithic raw materials in assemblages would be highly beneficial to future studies. Though the subjectivity of raw materials was mitigated in this study by reliance on broader macroscopic categories, with minimal likelihood of error, a detailed study with an accompanying minimum analytical nodule analysis would have significant potential for evaluating reoccupation (Hurst 2010).

Collectively, analysis of the archaeological record of the Medicine Bow Mountains demonstrates the diverse patterns of use and reuse which drove high elevation landscape use in the area through time. As a diverse cultural landscape, the Rawah Wilderness constitutes a palimpsest of repeat occupations and dynamic systems of reuse. The results of this study demonstrate the variability in its use through time, underpins its importance to the ancient occupants of northern Colorado, and reflects the long-term patterns surrounding the use of these high elevation landscapes. Following the work of Metcalf (1971a) and Morris et al. (1994), this study reinforces the rich potential of the Rawah Wilderness' archaeological record to address significant questions pertaining to Rocky Mountain prehistory and the archaeology of mountain landscapes.

REFERENCES CITED

Adams, Jenny L.

2002 *Ground Stone Analysis: A Technical Approach*. University of Utah Press. Salt Lake City, Utah.

Adams, Richard, Tory N. Taylor, Meredith E. Taylor, John B. Lund, Bryon A. Schroeder, Orrin Koenig, and Matthew A. Stirn

2014 Untrammeled by Man: Wilderness Archaeology in Wyoming. *The SAA Archaeological Record* 14(2):11-14.

Adams, Richard

2010 Archaeology with Altitude: Late Prehistoric Settlement and Subsistence in the Northern Wind River Range, Wyoming. Doctoral dissertation, Department of Anthropology, University of Wyoming, Laramie.

Agam, Aviad, and Lucy Wilson

2019 Blind Test Evaluation of Consistency in Macroscopic Lithic Raw Material Sorting. *Geoarchaeology* 34(4):467-477.

Andelt, W.F., and R.M. Case

2016 Managing Pocket Gophers. Fact Sheet No. 6.515. Colorado State University Extension.

Anderson, Kat M.

2005 *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources*. University of California Press, Berkeley.

Andrefsky, William, Jr.

1998 *Lithics: Macroscopic Approaches to Analysis*. Cambridge University Press, Cambridge.

2008 Projectile Point Provisioning Strategies and Human Land Use. In *Lithic Technology: Measures of Production, Use, and Curation*, edited by William Andrefsky, Jr., pp.195-215. Cambridge University Press, Cambridge.

Andrews, Brian N., Jason M. LaBelle, and John D. Seebach

2008 Spatial Variability in the Folsom Archaeological Record: A Multi-Scalar Approach. *American Antiquity* 73(3):464-490.

Bailey, Geoff

2007 Time Perspectives, Palimpsests and the Archaeology of Time. *Journal of Anthropological Archaeology* 26(2):198-223.

Baxter, M.J., and Christian C. Beardah

1997 Some Archaeological Applications of Kernel Density Estimates. *Journal of Archaeological Science* 24(4):347-354.

Bamforth, Douglas B.

2006 The Windy Ridge Quartzite Quarry: Hunter-Gatherer Mining and Hunter-Gatherer Land Use on the North American Continental Divide. *World Archaeology* 38(3):511-527

Barbour, Erwin H., and C. Bertrand Schultz

1932 The Scottsbluff Bison Quarry and its Artifacts. *Bulletin of the Nebraska State Museum* 34(1):283-286.

Beardah, Christian C.

1999 Uses of Multivariate Kernel Density Estimates in Archaeology. In *Archaeology in the Age of the Internet – CAA 97*, edited by Dingwall, L., S. Exon, V. Gaffney, S. Laflin and M. van Leusen. Proceedings of the 25th Anniversary Conference, University of Birmingham, April 1997. Archaeopress, Oxford.

Bechberger, Jillian M.

2010 Biogeomorphic Processes and Archaeological Site Formation in Absaroka Mountains of Northwestern Wyoming. Master's thesis, Department of Anthropology, Colorado State University, Fort Collins.

Bender, Susan J.

2015 Modeling Forager Settlements of Mountain Landscapes. In Rocky Mountain Archaeology: A Tribute to James Benedict, edited by Kenneth P. Cannon, Judson Byrd Finley, and Molly Boeka Cannon, pp. 299-321. *Plains Anthropologist* Memoir 43, 60(236):287-430.

Benedict, James B., and Bryon L. Olson

1978 *The Mount Albion Complex: A Study of Prehistoric Man and the Altithermal.* Research Report No. 1. Center for Mountain Archaeology, Ward, Colorado.

Benedict, James B.

1974 Early Occupation of the Caribou Lake Site, Colorado Front Range. *Plains Anthropologist* 19(63):1-4.

1975a The Murray Site: A Late Prehistoric Game Drive System in the Colorado Rocky Mountains. *Plains Anthropologist* 20(69):161-174.

1975b Scratching Deer: A Late Prehistoric Campsite in the Green Lakes Valley, Colorado. *Plains Anthropologist* 20(70):267-278.

1978 The Mount Albion Complex: Review and Summary. In *The Mount Albion Complex: A Study of Prehistoric Man and the Altithermal,* edited by James B. Benedict and Bryon L. Olson, pp. 118-138. Research Report No. 1. Center for Mountain Archaeology, Ward, Colorado.

1981 *The Fourth of July Valley: Glacial Geology and Archeology of the Timberline Ecotone*. Research Report No. 2. Center for Mountain Archeology, Ward, Colorado.

1985 *Arapaho Pass: Glacial Geology and Archaeology at the Crest of the Colorado Front Range.* Research Report No. 3. Center for Mountain Archeology, Ward, Colorado.

1989 Age of Punctate Pottery from the Caribou Lake Site: Comparison of Three Physical Dating Methods. *Southwestern Lore* 55(2):1-10.

1990 *Archeology of the Coney Creek Valley*. Research Report No. 5. Center for Mountain Archeology, Ward, Colorado.

1992 Footprints in the Snow: High-Altitude Cultural Ecology of the Colorado Front Range, U.S.A. *Arctic and Alpine Research* 24(1):1-16.

1996 *The Game Drives of Rocky Mountain National Park*. Research Report No. 7. Center for Mountain Archeology, Ward, Colorado.

2000 Excavations at the Fourth of July Mine Site. In *This Land of Shining Mountains: Archeological Studies in Colorado's Indian Peaks Wilderness Area*, edited by E. Steve Cassells, pp. 159-188. Research Report No. 8. Center for Mountain Archeology, Ward, Colorado.

2007 Effects of Climate on Plant-Food Availability at High Altitude in the Colorado Front Range, U.S.A. *Journal of Ethnobiology* 27(2): 143-173.

2012 Glaciers, Rockfall, Fire, and Flood: The Geologic History of the Spotted Pony Site. In Footprints in the Snow: Papers in Honor of James B. Benedict, edited by Jason M. LaBelle, E. Steve Cassells, and Michael D. Metcalf, pp. 70-85. *Southwestern Lore* 78(1):3-90.

Benner, Jourdan, Anders Knudby, Julie Nielsen, Meg Krawchuk, and Ken Lertzman

2019 Combining Data from Field Surveys and Archaeological Records to Predict the Distribution of Culturally Important Trees. *Diversity and Distributions* 25(9):1375-1387.

Bettinger, Robert L.

1991 Aboriginal Occupation of High Altitude: Alpine Villages in the White Mountains of Eastern California. *American Anthropologist* 93:656-679.

Binford, Lewis R.

1978 Dimensional Analysis of Behavior and Site Structure: Learning from an Eskimo Hunting Stand. *American Antiquity* 43(3):330-361.

1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35(3):255-273.

1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45(1):4-20.

1981 Behavioral Archaeology and the "Pompeii Premise". *Journal of Anthropological Research* 37(3):195-208.

1982 The Archaeology of Place. *Journal of Anthropological Archaeology* 1(1):5-31.

Black, Kevin D., and Aaron Theis

2015 Progress and Prospects in Geoarchaeological Research on Chert Sources in Central Colorado. In *Rocky Mountain Archaeology: A Tribute to James Benedict*, edited by Kenneth P. Cannon, Judson B. Finley, and Molly B. Cannon. *Plains Anthropologist* 60(236), Memoir 43: 337-354.

Black, Kevin D.

2000 Lithic Sources in the Rocky Mountains of Colorado. In *Intermountain Archaeology*, edited by David B. Madsen and Michael D. Metcalf, pp. 132-218. The University of Utah Press, Salt Lake City.

2019 Quarries Large and Small: A Comparison from Northern Colorado. Paper presented at the 14th Biennial Meeting of the Rocky Mountain Anthropological Association, Logan, Utah.

Blecha, Erika S.

2015 Into the Wild: A Case Study of the Intersection of Archaeology and Federal Wilderness Policy. Master's thesis, Department of Anthropology, University of Montana, Missoula.

Bobrowsky, Peter T., and Bruce F. Ball

1989 The Theory and Mechanics of Ecological Diversity in Archaeology. In *Quantifying Diversity in Archaeology*, edited by Robert D. Leonard and George T. Jones, pp. 4-12. Cambridge University Press, Cambridge.

Bocek, Barbara

1986 Rodent Ecology and Burrowing Behavior: Predicted Effects on Archaeological Site Formation. *American Antiquity* 51(3):589-603.

Bonnichsen, B. Robson, and James D. Keyser

1982 Three Small Points: A Cody Complex Problem. *Plains Anthropologist* 27(96):137-144.

Brunswig, Robert H., and David Diggs

2014 GIS Modeling of Intermediate Scale Lithic Landscapes in the Colorado Rockies: The Case of Ballinger Draw. In *Lithics in the West: Using Lithic Analysis to Solve Archaeological Problems in Western North America*, edited by Douglas H. MacDonald, William Andrefsky, Jr., and Pei-Lin Yu, pp. 75-96. The University of Montana Press, Missoula.

Brunswig, Robert and Bonnie Pitblado (ed.)

2007 *Frontiers in Colorado Paleoindian Archaeology: From the Dent Site to the Rocky Mountains*. University Press of Colorado, Boulder.

Brunswig, Robert H.

2007 Paleoindian Cultural Landscapes and Archaeology of North-Central Colorado's Southern Rockies. In *Frontiers in Colorado Paleoindian Archaeology: From the Dent Site to the Rocky Mountains*, edited by Robert Brunswig and Bonnie Pitblado, pp. 261-310. University Press of Colorado, Boulder.

Buckner, Paul

2019 2019 Archaeological Investigations in the Rawah Wilderness, Roosevelt National Forest, Colorado. Center for Mountain and Plains Archaeology Report 2019-8. Center for Mountain and Plains Archaeology, Department of Anthropology and Geography, Colorado State University. Prepared for Arapaho and Roosevelt National Forests and Pawnee National Grassland.

2020 An Archaeological Predictive Model for Lassen Volcanic National Park. Cultural Resources Technical Report, Deliverable No. 1. Department of Anthropology and Geography, Colorado State University. Prepared for Lassen Volcanic National Park.

Burnett, Paul

2005 Surface Lithic Scatters in the Central Absarokas of Wyoming. Master's thesis, Department of Anthropology, Colorado State University, Fort Collins.

Butler, William B.

1988 The Woodland Period in Northeastern Colorado. *Plains Anthropologist* 33(122):449-465.

Camilli, Eileen L., and James I. Ebert

1992 Artifact Reuse and Recycling in Continuous Surface Distributions and Implications for Interpreting Land Use Patterns. In *Space, Time, and Archaeological Landscapes*, edited by Jacqueline Rossignol and LuAnn Wandsnider, pp. 113-136. Plenum Press, New York.

Chakraborty, Anusheema, P.K. Joshi, and Kamna Sachdeva

2016 Predicting Distribution of Major Forest Tree Species to Potential Impacts of Climate Change in the Central Himalayan Region. *Ecological Engineering* 97:593-609.

Chatters, James C.

1987 Hunter-Gatherer Adaptations and Assemblage Structure. *Journal of Anthropological Research* 6(4):336-375.

Chenault, Mark L.

1999 Introduction. In *Colorado Prehistory: A Context for the Platte River Basin*, edited by K.P. Gilmore, M. Tate, M.L. Chenault, B. Clark, T. McBride, and M. Wood, pp. 1-6. Colorado Council of Professional Archaeologists, Denver.

Clark, Jeffrey J., and Patricia A. Gilman

2012 Persistent and Permanent Pithouse Places in the Basin and Range Province of Southeastern Arizona. In *Southwestern Pithouse Communities, AD 200 – 900*, edited by Lisa C. Young and Sarah A. Herr, pp. 61-77. University of Arizona Press, Tucson, Arizona.

Clarkson, Chris

2008 Changing Reduction Intensity, Settlement, and Subsistence in Wardaman Country, Northern Australia. In *Lithic Technology: Measures of Production, Use, and Curation*, edited by William Andrefsky, Jr., pp. 286-316. Cambridge University Press, Cambridge.

Conkey, Margaret W.

1989 The Use of Diversity in Stylistic Analysis. In *Quantifying Diversity in Archaeology*, edited by Robert D. Leonard and George T. Jones, pp. 118-129. Cambridge University Press, Cambridge.

Cronon, William

1995 The Trouble with Wilderness; or, Getting Back to the Wrong Nature. In *Uncommon Ground: Rethinking the Human Place in Nature*, edited by William Cronon, pp. 69-90. W. W. Norton & Co., New York.

Czubernat, Amberle

2019 Patterns in Production: A Minimum Analytical Nodule Analysis (MANA) of a High Altitude Locality in the Medicine Bow Mountain Range, Larimer County, Colorado. Poster presented at the 41st Annual Meeting of the Colorado Council of Professional Archaeologists, Durango, Colorado.

Daniel, Jeffrey T.

2014 Diagnostic Methods for Maxent Models in Ecology. Master's thesis, Department of Mathematics and Statistics, University of Guelph, Ontario.

Davies, Benjamin, Simon J. Holdaway, and Patricia C. Fanning

2016 Modelling the Palimpsest: An Exploratory Agent-Based Model of Surface Archaeological Deposit Formation in a Fluvial Arid Australian Landscape. *The Holocene* 26(3):450-463.

Davies, Benjamin, and Simon J. Holdaway

2018 Windows on the Past? Perspectives on Accumulation, Formation, and Significance from an Australian Holocene Lithic Landscape. *Mitteilungen der Gesellschaft für Urgeschichte* 26:125-152.

Dooley, Mathew A.

2004 Long-Term Hunter-Gatherer Land Use in Central North Dakota: An Environmental Analysis. *Plains Anthropologist* 49(190):105-127.

2008 Investigating Persistent Places in the Northern Great Plains, Central North Dakota. In *Time in Archaeology: Time Perspectivism Revisited*, edited by Simon Holdaway and LuAnn Wandsnider, pp. 94-109. The University of Utah Press, Salt Lake.

Dormann, C.F., Elith, J., Bacher, S., Buchmann, C., Carl, G., Carré, G., Marquéz, J.R.G., Gruber, B., Lafourcade, B., Leitão, P.J., Münkemüller, T., McClean, C., Osborne, P.E., Reineking, B., Schröder, B., Skidmore, A.K., Zurell, D., Lautenbach, S.,
2013 Collinearity: A Review of Methods to Deal with it and a Simulation Study Evaluating Their Performance. *Ecography* 36(1):27–46.

Dormann, Carsten F.
2011 Modelling Species' Distributions. In *Modelling Complex Ecological Dynamics: An Introduction into Ecological Modelling,* edited by Fred Jopp, Hauke Reuter, and Broder Breckling, pp. 179-196. Springer, New York.

Downum, Christian E., and Gregory B. Brown
1998 The Reliability of Surface Artifact Assemblages as Predictors of Subsurface Remains. In *Surface Archaeology*, edited by Alan P. Sullivan III, pp. 111-124. University of New Mexico Press, Albuquerque.

Driscoll, Killian
2011 Vein Quartz in Lithic Traditions: An Analysis Based on Experimental Archaeology. *Journal of Archaeological Science* 38(3):734-745.

Dunnell, Robert C., and William S. Dancey
1983 The Siteless Survey: A Regional Scale Data Collection Strategy. In *Advances in Archaeological Method and Theory*, edited by Michael B. Schiffer, pp. 267-288. Academic Press, New York.

Dunnell, Robert C.
1992 The Notion Site. In *Space, Time, and Archaeological Landscapes,* edited by Jacqueline Rossignol and LuAnn Wandsnider, pp. 21-41. Plenum Press, New York.

Eighmy, Jeffrey L., and Jason M. LaBelle
1996 Radiocarbon Dating of Twenty-Seven Plains Complexes and Phases. *Plains Anthropologist* 41(155):53-69.

Elith, Jane, Steven J. Phillips, Trevor Hastie, Miroslav Dudik, Yung En Chee, and Colin J. Yates
2010 A Statistical Explanation of MaxEnt for Ecologists. *Diversity and Distributions* 17(1):1-15.

Feng, Xiao, Daniel S. Park, Ye Liang, Ranjit Pandey, and Monica Papes
2019 Collinearity in Ecological Niche Modeling: Confusions and Challenges. *Ecology and Evolution* 9(18):10365-10376.

Frison, George C., and Lawrence C. Todd (ed.)
1987 The Horner Site: The Type Site of the Cody Cultural Complex. Academic Press, Orlando.

Frison, George C.

1991 *Prehistoric Hunters of the High Plains.* 2nd ed. Academic Press, San Diego.

Galletti, Christopher S., Elizabeth Ridder, Steven E. Falconer, and Patricia L. Fall

2013 Maxent Modeling of Ancient and Modern Agricultural Terraces in the Troodos Foothills, Cyprus. *Applied Geography* 39:46-56.

Gallivan, Martin D.

2002 Measuring Sedentariness and Settlement Population: Accumulations Research in the Middle Atlantic Region. *American Antiquity* 67(3):535-557.

Gamble, Lynn H.

2017 Feasting, Ritual Practices, Social Memory, and Persistent Places: New Interpretations of Shell Mounds in Southern California. *American Antiquity* 82(3):427-451.

Gilmore, Kevin P.

1991 Bayou Gulch: Geoarchaeology of a Multicomponent Site in Central Colorado. Master's thesis, Department of Anthropology, University of Colorado, Boulder.

1999 Late Prehistoric Stage. In *Colorado Prehistory: A Context for the Platte River Basin*, edited by K.P. Gilmore, M. Tate, M.L. Chenault, B. Clark, T. McBride, and M. Wood, pp. 175-305. Colorado Council of Professional Archaeologists, Denver.

Gooding, John D.

1981 The Archaeology of Vail Pass Camp: A Multi-Component Base Camp Below Treelimit in the Southern Rockies. Highway Salvage Report No. 35. University of Colorado Museum.

Healy, A., C.D. Lippit, D. Phillips, and M. Lane

2017 A Comparison of Suitability Models to Identify Prehistoric Agricultural Fields in Western New Mexico. *Journal of Archaeological Science* 11:427-434.

Heilen, Michael, Phillip O. Leckman, Adam Byrd, Jeffrey A. Homburg, and Robert A. Heckman

2013 Archaeological Sensitivity Modeling in Southern New Mexico: Automated Tools and Models for Planning and Management. Statistical Research, Inc. Technical Report 11-26.

Holdaway, Simon, Patricia Fanning, and Ed Rhodes

2008 Assemblage Accumulation as a Time-Dependent Process in the Arid Zone of Western New South Wales, Australia. In *Time in Archaeology: Time Perspectivism Revisited*, edited by Simon Holdaway and LuAnn Wandsnider, pp. 110-133. The University of Utah Press, Salt Lake City.

Holmer, Richard N.
1986 Common Projectile Points of the Intermountain West. In *Anthropology of the Desert West: Essays in Honor of Jesse D. Jennings*, edited by C. Condie and D.D. Fowler, pp. 90-115. Anthropological Papers No. 110. University of Utah, Salt Lake City.

Holton, Jerry Thomas
2014 Predictive Model of Archaeological Sites on the Hopi Reservation of Northeastern Arizona. Master's project, Department of Geographic Information Science, University of Redlands, Redlands.

Howey, Meghan C. L., Michael W. Palace, and Crystal H. McMichael
2016 Geospatial Modeling Approach to Monument Construction Using Michigan from A.D. 1000 – 1600 as a Case Study. *PNAS* 113(27):7443-7448.

Hurst, Stance, Eileen Johnson, Vance T. Holliday, and Sophie Butler
2010 Playa Archaeology on the Southern High Plains of Texas: A Spatial Analysis of Hunter-Gatherer Occupation at Tahoka-Walker (41LY53). *Plains Anthropologist* 55(215):195-214.

Husted, Wilfred M.
1965 Early Occupation of the Colorado Front Range. *American Antiquity* 30(4):494-498.

Ives, Ronald L.
1942 Early Human Occupation of the Colorado Headwaters Region: An Archeological Reconnaissance. *Geographical Review* 32(3):448-462.

Jaynes, E.T.
1957 Information Theory and Statistical Mechanics. *Physical Review* 106(4):620-630.

Johnston, Christopher M.
2016 Running of the Buffalo: Investigations of the Roberts Ranch Buffalo Jump (5LR100), Northern Colorado. Master's thesis, Department of Anthropology, Colorado State University, Fort Collins.

Jones, George T., and Robert D. Leonard
1989 The Concept of Diversity: An Introduction. In *Quantifying Diversity in Archaeology*, edited by Robert D. Leonard and George T. Jones, pp. 1-3. Cambridge University Press, Cambridge.

Joyes, Dennis C.
2000 Cody Technology at the McLeod Site, Saskatchewan, Canada. *Current Research in the Pleistocene* 17:47-49.

Kailihiwa, Solomon Ha'aheo, III

2015 Using Maxent to Model the Distribution of Prehistoric Agricultural Features in a Portion of the Hokuli'a Subdivision in Kona, Hawai'i. Master's thesis, Department of Geographic Information Science and Technology, University of Southern California, Los Angeles.

Kalle, Riddhika, Tharmalingam Ramesh, Qamar Qureshi, and Kalyanasundaram Sankar

2013 Predicting the Distribution Pattern of Small Carnivores in Response to Environmental Factors in the Western Ghats. *Plos One* 8(11):1-13.

Kaufman, Daniel

1998 Measuring Archaeological Diversity: An Application of the Jackknife Technique. *American Antiquity* 63(1):73-85.

Kelly, Robert L.

2013 *The Lifeways of Hunter-Gatherers: The Foraging Spectrum*. Cambridge University Press, Cambridge.

Koenig, Orrin

2018 2018 Rawah Wilderness Survey Notes. Unpublished field notes. On file with the Heritage Resource Management Program, Arapaho and Roosevelt National Forests and Pawnee National Grassland. Fort Collins, Colorado.

Kvamme, Kenneth L.

1977 Aboriginal Sandstone Quarries in the Foothills of Northeastern Colorado. *Southwestern Lore* 43(3):22-26.

1988a A Simple Graphic Approach and Poor Man's Clustering Technique for Investigating Surface Lithic Scatter Types. *Plains Anthropologist* 33(121):385-394.

1988b Development and Testing of Quantitative Models. In *Quantifying the Present and Predicting the Past: Theory, Method, and Application of Archaeological Predictive Modeling*, edited by W. James Judge and Lynne Sebastian, pp. 325-428. Bureau of Land Management, Denver, Colorado.

1988c Using Existing Archaeological Survey Data for Model Building. In *Quantifying the Present and Predicting the Past: Theory, Method, and Application of Archaeological Predictive Modeling*, edited by W. James Judge and Lynne Sebastian, pp. 301-324. Bureau of Land Management, Denver, Colorado.

1992 A Predictive Site Location Model on the High Plains: An Example with an Independent Test. *Plains Anthropologist* 37(138):19-40.

1998 Spatial Structure in Mass Debitage Scatters. In *Surface Archaeology*, edited by Alan P. Sullivan III, pp. 127-142. University of New Mexico Press, Albuquerque.

LaBelle, Jason M., and Steven R. Holen

2008 Evidence for Multiple Paleoindian Components at the Lindenmeier Site, Larimer County, Colorado. *Current Research in the Pleistocene* 25:108-110.

LaBelle, Jason M., and Kelton Meyer

2017 Paleo-Indian Occupation of the Medicine Bow Mountains of Northern Colorado: A Consideration of Archaeological and Paleoclimatic Data. Paper presented at the 13th Biennial Meeting of the Rocky Mountain Anthropological Association, Canmore, Alberta.

LaBelle, Jason M.

2005 Hunter-Gatherer Foraging Variability During the Early Holocene of the Central Plains of North America. Doctoral dissertation, Department of Anthropology, Southern Methodist University, Dallas.

2009 Shiny Black Rocks: Exploring the Role of Obsidian in Interregional Contact within the South Platte Basin. Paper presented to the 31st annual meeting of the Colorado Council of Professional Archaeologists, Alamosa, Colorado.

2010 *Re*Occupation of Place: Late Paleoindian Land Use Strategies in the Central Plains. In *Exploring Variability in Early Holocene Hunter-Gatherer Lifeways*, edited by Stance Hurst and Jack L. Hofman, pp. 37-72. University of Kansas Publication in Anthropology 25. Mainline Printing, Topeka.

2012 Hunter-Gatherer Adaptations of the Central Plains and Rocky Mountains of Western North America. In *Hunter-Gatherer Behavior: Human Response During the Younger Dryas*, edited by Metin I. Eren, pp. 139-164. Left Coast Press, Walnut Creek.

2015a Shovel Testing the Fossil Creek Site (5LR13041): An Early Ceramic Period Native American Campsite in Larimer County, Colorado. Center for Mountain and Plains Archaeology Report 2015-03. Center for Mountain and Plains Archaeology, Department of Anthropology, Colorado State University. Prepared for the City of Fort Collins Natural Areas Program.

2015b An Introduction to the Lithic Caches of Colorado. *Southwestern Lore* 81(2):1-24.

Landt, Matthew J., and Michael J. Prouty

2017 Prehistoric Ground Stone Caches in the Spring Creek Drainage, Moffat County, Colorado. *Southwestern Lore* 83(2):1-20.

Larson, Mary Lou

1994 Towards a Holistic Analysis of Chipped Stone Assemblages. In *The Organization of North American Prehistoric Chipped Stone Tool Technologies*, edited by Phillip J. Carr, pp. 57-69. International Monographs in Prehistory, Archaeology Series 7, Ann Arbor.

Lee, Sang-Il

2017 Correlation and Spatial Autocorrelation. In *Encyclopedia of GIS*, edited by S. Shekhar, H. Xiong, and X. Zhou. Springer Publishing, New York.

Lee, Craig M.

2012 Withering Snow and Ice in the Mid-Latitudes: A New Archaeological and Paleobiological Record for the Rocky Mountain Region. *Arctic* 65(1):165-177.

Lischka, Joseph J., Mark E. Miller, R. Branson Reynolds, Dennis Dahms, Kathie Joyner-McGuire, and David McGuire

1983 An Archaeological Inventory in North Park, Jackson County, Colorado. Cultural Resources Series Number 14. Bureau of Land Management, Denver.

MacDonald, Douglas H.

2008 The Role of Lithic Raw Material Availability and Quality in Determining Tool Kit Size, Tool Function, and Degree of Retouch: A Case Study from Skink Rockshelter (46NI445), West Virginia. In *Lithic Technology: Measures of Production, Use, and Curation*, edited by William Andrefsky, Jr., pp. 216-232. Cambridge University Press, Cambridge.

McMahon, Todd C.

2004 Colorado Prehistoric Resource Spatial Interpolation Using a Kernel Density Estimate Method. *Southwestern Lore* 70(4):5-25.

McMichael, C.H., M.W. Palace, M.B. Bush, B. Braswell, S. Hagen, E.G. Neves, M.R. Silman, E.K. Tamanaha, and C. Czarnecki

2014 Predicting Pre-Columbian Anthropogenic Soils in Amazonia. *Proceedings of the Royal Society B* 281:1-9.

Meeker, Halston F. C., Jason M. LaBelle, Aaron Whittenburg, and Michelle Dinkel

2016 CMPA Site Reconnaissance and Shovel Testing in the Poudre River Canyon and Indian Peaks, Colorado. Center for Mountain and Plains Archaeology Report 2016-03. Center for Mountain and Plains Archaeology, Department of Anthropology, Colorado State University. Prepared for Arapaho and Roosevelt National Forests and Pawnee National Grassland.

Meeker, Halston F. C.

2017 Measuring Occupation Span at Two Stone Circle Sites in Larimer County, Colorado. Master's thesis, Department of Anthropology, Colorado State University, Fort Collins.

Meltzer, David, Robert D. Leonard, and Susan K. Stratton

1992 The Relationship between Sample Size and Diversity in Archaeological Assemblages. *Journal of Archaeological Science* 19(4):375-387.

Metcalf, Michael D.

1971a Rawah Survey Notes. Unpublished field notes. On file with the Center for Mountain and Plains Archaeology, Department of Anthropology and Geography, Colorado State University. Fort Collins, Colorado

1971b 5LR237 Site Recording Card. Accessed from the Colorado State University archaeological repository.

Meaney, Carron A., and Dirk Van Vuren

1993 Recent Distribution of Bison in Colorado West of the Great Plains. *Proceedings of the Denver Museum of Natural History* 3(4):1-10.

Meyer, Kelton A., and Jason M. LaBelle

2017 On the Trail with Mike Metcalf and Liz Morris: Reinvestigation of the Carey Lake Site, Larimer County. Paper presented to the 39th annual meeting of the Colorado Council of Professional Archaeologists, Grand Junction, Colorado.

Meyer, Kelton A.

2018 Investigation of the Carey Lake Site (5LR230): Report of the 2017 Field Season in the Rawah Wilderness, Larimer County. Center for Mountain and Plains Archaeology Report 2018-2. Center for Mountain and Plains Archaeology, Department of Anthropology, Colorado State University. Prepared for Arapaho and Roosevelt National Forests and Pawnee National Grassland.

2019a Absolute and Relative Chronology of a Complex Alpine Game Drive Site (5BL148), Rollins Pass, Colorado. Master's thesis, Department of Anthropology, Colorado State University, Fort Collins.

2019b Investigation of the Carey Lake Site (5LR230): Report of the 2018 Field Season in the Rawah Wilderness Area, Larimer County. Center for Mountain and Plains Archaeology Report 2019-2. Center for Mountain and Plains Archaeology, Department of Anthropology and Geography, Colorado State University. Prepared for Arapaho and Roosevelt National Forests and Pawnee National Grassland.

2019c Investigation of the Carey Lake Site (5LR230): Report of the 2019 Field Season in the Rawah Wilderness, Larimer County. Center for Mountain and Plains Archaeology Report 2019-7. Center for Mountain and Plains Archaeology, Department of Anthropology and Geography, Colorado State University. Prepared for Arapaho and Roosevelt National Forests and Pawnee National Grassland.

Mitchell, Mark D.

2012 High-Altitude Archaeology in the Uncompahgre Wilderness. Research Contribution No. 87. Paleocultural Research Group, Arvada, Colorado.

Morgan, Christopher, Ashley Losey, and Richard Adams

2012 High-Altitude Hunter-Gatherer Residential Occupations in Wyoming's Wind River Range. *North American Archaeologist* 33(1):35-79.

Morgan, Christopher, Molly Boeka Cannon, and Benjamin Fowler

2013 Statistical Means for Identifying Hunter-Gatherer Residential Features in a Lithic Landscape. *Journal of Archaeological Science* 40(8):3117-3128.

Morgan, Christopher, Dallin Webb, Kari Sprengeler, Marielle (Pedro) Black, and Nicole George

2018 Experimental Construction of Hunter-Gatherer Residential Features, Mobility, and the Costs of Occupying "Persistent Places". *Journal of Archaeological Science* 91:65-76.

Morris, Elizabeth A., and James R. Marcotte
1976 Archaeological Investigations on the Joe Wright Reservoir Project, A High Altitude Locality in Northern Colorado. Cultural Resource Management Report 7. Laboratory of Public Archaeology, Colorado State University.

Morris, Elizabeth A., and Michael D. Metcalf
1993 Twenty-Two Years of Archaeological Survey in the Rawah Area, Medicine Bow Mountains, Northern Colorado. In *Abstracts of Papers, 1st Biennial Rocky Mountain Anthropology Conference*. Jackson, Wyoming.

Morris, Elizabeth A., Richard C. Blakeslee, and Michael D. Metcalf
1994 Prehistoric Utilization of a High Altitude Area in the Rocky Mountains in Northern Colorado. *Acta Archaeologica Carpathica* 32:65-75.

Morris, Elizabeth A.
2010 Paleoindian Projectile Points from an 11,000-ft Site in the Rocky Mountains, Northern Colorado. *Current Research in the Pleistocene* 27:123-124.

Mulloy, William
1959 The James Allen Site, Near Laramie, Wyoming. *American* Antiquity 25(1):112-116.

Nelson, Charles E. and Bruce G. Stewart
1973 Cherokee Mountain Rock Shelter. *Plains Anthropologist* 18(62):328-335.

Nelson, Charles E.
1971 The George W. Lindsay Ranch Site, 5JF11. *Southwestern Lore* 37(1):1-14.

Noviello, Mariangela, Barbara Cafarelli, Crecenza Calculli, Apostolos Sarris, and Paola Mairota
2018 Investigating the Distribution of Archaeological Sites: Multiparametric vs. Probability Models and Potentials for Remote Sensing Data. *Applied Geography* 95:34-44.

Oyarzun, Megan C.
2016 Predicting Archaeological Site Locations in Northeastern California's High Desert using the Maxent Model. Master's thesis, Department of Geographic Information Science and Technology, University of Southern California, Los Angeles.

Page, Michael K.
2017 The Game Creek Site and the Prehistory of Jackson Hole. The Office of the Wyoming State Archaeologist, Wyoming Department of State Parks and Cultural Resources. Prepared for the Teton County Public Library.

Pearson, Richard D.
2010 Species' Distribution Modeling for Conservation Educators and Practitioners. *Lessons in Conservation* 3:54-89.

Pelton, Spencer R., Jason M. LaBelle, and Chris Davis

2016 The Spring Canyon Site: Prehistoric Occupation of a Hogback Water Gap in the Foothills of Larimer County, Colorado. *Southwestern Lore* 82(1):1-20.

Pelton, Spencer R.

2013 Ground Stone Lithic Technology of the Indian Peaks, Colorado, USA. Master's thesis, Department of Anthropology, Colorado State University, Fort Collins.

2017 Provisioning the High Country: A Distributional Analysis of Ground Stone Tools from the Colorado Front Range. *Plains Anthropologist* 62(243):247-268.

Perlmutter, Benjamin

2015 Bringing it all Back Home: Early Ceramic Period Residential Occupation at the Kinney Spring Site (5LR144C), Larimer County, Colorado. Master's thesis, Department of Anthropology, Colorado State University, Fort Collins.

Phillips, Steven J., Miroslav Dudik, Robert E. Schapire

n.d. Maxent Software for Modeling Species Niches and Distributions (Version 3.4.1), http://biodiversityinformatics.amnh.org/open_source/maxent/, accessed February 1, 2019.

Phillips, Steven J.

2017 A Brief Tutorial on Maxent. Unpublished Technical Document. http://biodiversityinformatics.amnh.org/open_source/maxent/, accessed February 1, 2019.

Pitblado, Bonnie L., C.W. Merriman, and Caroline Gabe

2007 Assessing Integrity at the Paleoindian-Historic Capitol City Moraine Site (5HN510), Hinsdale County, Colorado. *Southwestern Lore* 73(3):21-44.

Pitblado, Bonnie L.

2000 Living the High Life in Colorado: Late Paleoindian Occupation of the Caribou Lake Site. In *This Land of Shining Mountains: Archeological Studies in Colorado's Indian Peaks Wilderness Area*, edited by E. Steve Cassells, pp. 124-158. Research Report No. 8. Center for Mountain Archeology, Ward, Colorado.

2003 *Late Paleoindian Occupation of the Southern Rocky Mountains: Early Holocene Projectile Points and Land Use in the High Country.* University Press of Colorado, Boulder.

2007 Angostura, Jimmy Allen, Foothills-Mountain: Clarifying Terminology for Late Paleoindian Southern Rocky Mountain Spear Points. In *Frontiers in Colorado Paleoindian Archaeology: From the Dent Site to the Rocky Mountains*, edited by Robert Brunswig and Bonnie Pitblado, pp. 311-337. University Press of Colorado, Boulder.

Proosdij, Andre S., Marc S. M. Sosef, Jan J. Wieringa, and Niels Raes

2015 Minimum Required Number of Specimen Records to Develop Accurate Species Distribution Models. *Ecography* 39(6):542-552.

Pyszcyk, Heinz
1984 Site Occupation Length as a Factor in Artifact Assemblage Variability and Frequency. *Archaeological Survey of Alberta, Occasional Paper 23*:60-76.

Rademaker, Kurt, and Katherine Moore
2019 Variation in the Occupation Intensity of Early Forager Sites of the Andean Puna: Implications for Settlement and Adaptation. In *Foraging in the Past: Archaeological Studies of Hunter-Gatherer Diversity*, edited by Ashley K. Lemke, pp. 76-118. University Press of Colorado, Boulder.

Reckin, Rachel, and Lawrence C. Todd
2020 Illuminating High Elevation Seasonal Occupational Duration Using Diversity in Lithic Raw Materials and Tool Types in the Greater Yellowstone Ecosystem, USA. *Journal of Anthropological Archaeology* 57:1-15.

Rindos, David
1989 Diversity, Variation, and Selection. In *Quantifying Diversity in Archaeology*, edited by Robert D. Leonard and George T. Jones, pp. 13-23. Cambridge University Press, Cambridge.

Sauer, Carl O.
1925 The Morphology of Landscape. *University of California Publications in Geography* 2(2):19-54.

Scheiber, Laura L., and María Nieves Zedeño
2015 Introduction. In *Engineering Mountain Landscapes: An Anthropology of Social Investment*, edited by Laura L. Scheiber and María Nieves Zedeño, pp. 1-6. The University of Utah Press, Salt Lake.

Schiffer, Michael B.
1975 The Effects of Occupation Span on Site Content. In *The Cache River Archeological Project: An Experiment in Contract Archeology*, edited by Michael B. Schiffer and John H. House, pp. 265-269. Research Series No. 8, Arkansas Archeological Survey.
1987 *Formation Processes of the Archaeological Record*. University of New Mexico Press, Albuquerque.

Schlanger, Sarah H.
1990 Artifact Assemblage Composition and Site Occupation Duration. In *Perspectives on Southwestern Prehistory*, edited by Paul E. Minnis and Charles L. Redman, pp. 103-121. Westview Press, Boulder.
1992 Recognizing Persistent Places in Anasazi Settlement Systems. In *Space, Time, and Archaeological Landscapes*, edited by Jacqueline Rossignol and LuAnn Wandsnider, pp. 91-112. Plenum Press, New York.

Seabloom, Eric W., O.J. Reichman, and Emmanuel J. Gabet

2000 The Effect of Hillslope Angle on Pocket Gopher (*Thomomys bottae)* Burrow Geometry. *Oecologia* 125:26-34.

Shannon, Claude E., and Warren Weaver

1949 *The Mathematical Theory of Communication*. University of Illinois Press, Urbana.

Shiner, Justin

2009 Persistent Places: An Approach to the Interpretation of Assemblage Variation in Deflated Surface Stone Artefact Distributions from Western New South Wales, Australia. In *New Directions in Archaeological Science*, edited by Andrew Fairbairn, Sue O'Connor, and Ben Marwick, pp. 25-41. ANU Press, Canberra.

Shropshire, Lee

2003 Geologic Sources of Sandstones and Assorted Other Rock Types of Prehistoric Grinding Stone (Metate) Artifacts from University of Northern Colorado Archaeological Investigations in Rocky Mountain Park, North Central Colorado. Department of Anthropology, University of Northern Colorado. Prepared for Rocky Mountain National Park.

Silverman, Bernard W.

1986 *Density Estimation for Statistics and Data Analysis*. Monographs on Statistics and Applied Probability 26. CRC Press, Boca Raton.

Simek, Jan F.

1989 Structure and Diversity in Intrasite Spatial Analysis. In *Quantifying Diversity in Archaeology*, edited by Robert D. Leonard and George T. Jones, pp. 59-68. Cambridge University Press, Cambridge.

Simmons, Alan H.

1998 Exposed Fragments, Buried Hippos: Assessing Surface Archaeology. In *Surface Archaeology*, edited by Alan P. Sullivan III, pp. 159-168. University of New Mexico Press, Albuquerque.

Smith, Craig S., and Lance M. McNees

1999 Facilities and Hunter-Gatherer Long-Term Land Use Patterns: An Example from Southwest Wyoming. *American Antiquity* 64(1):117-136.

2011 Persistent Land Use Patters and the Mid-Holocene Housepits of Wyoming. *Journal of Field Archaeology* 36(4):298-311.

Stavrova, T., A. Borel, C. Daujeard, and D. Vettese

2019 A GIS Based Approach to Long Bone Breakage Patterns Derived from Marrow Extraction. *Plos One* 14(5):1-26.

Stiger, Mark

2001 *Hunter-Gatherer Archaeology of the Colorado High Country*. University Press of Colorado, Boulder.

Sullivan, Alan P., III, and Anthony S. Tolonen

1998 Evaluating Assemblage Diversity Measures with Surface Archaeological Data. *Surface Archaeology*, edited by Alan P. Sullivan III, pp. 143-155. University of New Mexico Press, Albuquerque.

Sullivan, Alan P., III

1992 Investigating the Archaeological Consequences of Short-Duration Occupations. *American Antiquity* 57(1):99-115.

1998 Surface Phenomena in Archaeological Research. In *Surface Archaeology*, edited by Alan P. Sullivan III, pp. XI-XIII. University of New Mexico Press, Albuquerque.

2008 Time Perspectivism and the Interpretive Potential of Palimpsests: Theoretical and Methodological Considerations of Assemblage Formation History and Contemporaneity. In *Time in Archaeology: Time Perspectivism Revisited*, edited by Simon Holdaway and LuAnn Wandsnider, pp. 31-45. The University of Utah Press, Salt Lake City.

Surovell, Todd A., Nicole Waguespack, James Mayer, Marcel Kornfeld, and George C. Frison

2005 Shallow Site Archaeology: Artifact Dispersal, Stratigraphy, and Radiocarbon Dating at the Barger Gulch Locality B Folsom Site, Middle Park, Colorado. *Geoarchaeology* 20(6):627-649.

Surovell, Todd A.

2009 *Toward a Behavioral Ecology of Lithic Technology: Cases from Paleoindian Archaeology*. The University of Arizona Press, Tucson.

Swets, J. A.

1988 Measuring the Accuracy of Diagnostic Systems. *Science* 240(4857):1285-1293.

Tate, Marcia

1999 Archaic Stage. In *Colorado Prehistory: A Context for the Platte River Basin*, edited by K.P. Gilmore, M. Tate, M.L. Chenault, B. Clark, T. McBride, and M. Wood, pp. 91-174. Colorado Council of Professional Archaeologists, Denver.

Tobler, W. R.

1970 A Computer Movie Simulating Urban Growth in the Detroit Region. *Economic Geography* 46:234-240.

Todd, Lawrence C., David C. Jones, Robert S. Walker, Paul C. Burnett, and Jeffrey Eighmy

2001 Late Archaic Bison Hunters in Northern Colorado: 1997-1999 Excavations at the Kaplan-Hoover Bison Bonebed (5LR3953). *Plains Anthropologist* 46(176):125-147.

United States Department of Agriculture (USDA)

2013 Four Band Digital Imagery: Information Sheet. Electronic Document, https://www.fsa.usda.gov/Internet/FSA_File/fourband_info_sheet_2013.pdf, accessed March 24, 2020.

Varien, Mark D., and Barbara J. Mills

1997 Accumulations Research: Problems and Prospects for Estimating Site Occupation Span. *Journal of Archaeological Method and Theory* 4(2):141-191.

Veblen, Thomas T., and Joseph A. Donnegan

2005 Historical Range of Variability for Forest Vegetation of the National Forests of the Colorado Front Range. Department of Geography, University of Colorado, Boulder. Report prepared for the USDA Forest Service, Rocky Mountain Region.

Verhagen, Philip, and Thomas G. Whitley

2012 Integrating Archaeological Theory and Predictive Modeling: A Live Report from the Scene. *Journal Archaeological Method and Theory* 19(1):49-100.

Walker, Samantha

2019 The Persistence of Place: Hunter-Gatherer Mortuary Practices and Land-Use in the Trent Valley, Ontario. *Journal of Anthropological Archaeology* 54:113-148.

Wandsnider, LuAnn, and Eileen L. Camilli

1992 The Character of Surface Archaeological Deposits and its Influence on Survey Accuracy. *Journal of Field Archaeology* 19(2):169-188.

Wandsnider, LuAnn

1992 The Spatial Dimension of Time. In *Space, Time, and Archaeological Landscapes*, edited by Jacqueline Rossignol and LuAnn Wandsnider, pp. 257-274. Plenum Press, New York.

2008 Time-Averaged Deposits and Multitemporal Processes in the Wyoming Basin, Intermontane North America: A Preliminary Consideration of Land Tenure in Terms of Occupation Frequency and Integration. In *Time in Archaeology: Time Perspectivism Revisited*, edited by Simon Holdaway and LuAnn Wandsnider, pp. 61-93. The University of Utah Press, Salt Lake City.

Wettlaufer, Boyd N.

1955 *The Mortlach Site in the Besant Valley of Central Saskatchewan*. Anthropological Series No. 1. Department of Natural Resources, Regina, Saskatchewan.

Wheat, Joe Ben

1947 5LR17 Site Form. University of Colorado Museum. On file with the Office of Archaeology and Historic Preservation (OAHP), Denver, Colorado.

Whittenburg, Aaron M.

2017 Communal Hunting in the Colorado High Country: Archaeological Investigations of Three Game Drive Sites Near Rollins Pass, Grand County, Colorado. Master's thesis, Department of Anthropology, Colorado State University, Fort Collins.

Winchell, Eric William

2017 Understanding the Geomorphic Imprint of the Northern Pocket Gopher on the Subalpine Zone of the Colorado Front Range. Doctoral dissertation, Department of Geological Sciences, University of Colorado, Boulder.

Workman, J.B., J.C. Cole, R.R. Shroba, K.S. Kellogg, W.R. Premo

2018a Geologic Map of the Fort Collins 30'x60' Quadrangle, Larimer and Jackson Counties, Colorado, and Albany and Laramie Counties, Wyoming. U.S. Geological Survey Scientific Investigations, Map 3399.

2018b Pamphlet to accompany Geologic Map of the Fort Collins 30'x60' Quadrangle, Larimer and Jackson Counties, Colorado, and Albany and Laramie Counties, Wyoming. U.S. Geological Survey Scientific Investigations, Map 3399.

Wormington, Marie H.

1957 *Ancient Man in North America.* Denver Museum of Natural History, Popular Series No. 4. Peerless Printing Company, Denver.

Young, Nick, Lane Carter and Paul Evangelista

2011 A MaxEnt Model v3.3.3e Tutorial (ArcGIS v10). Unpublished Technical Document. Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado.

Zilio, Leandro and Heidi Hammond

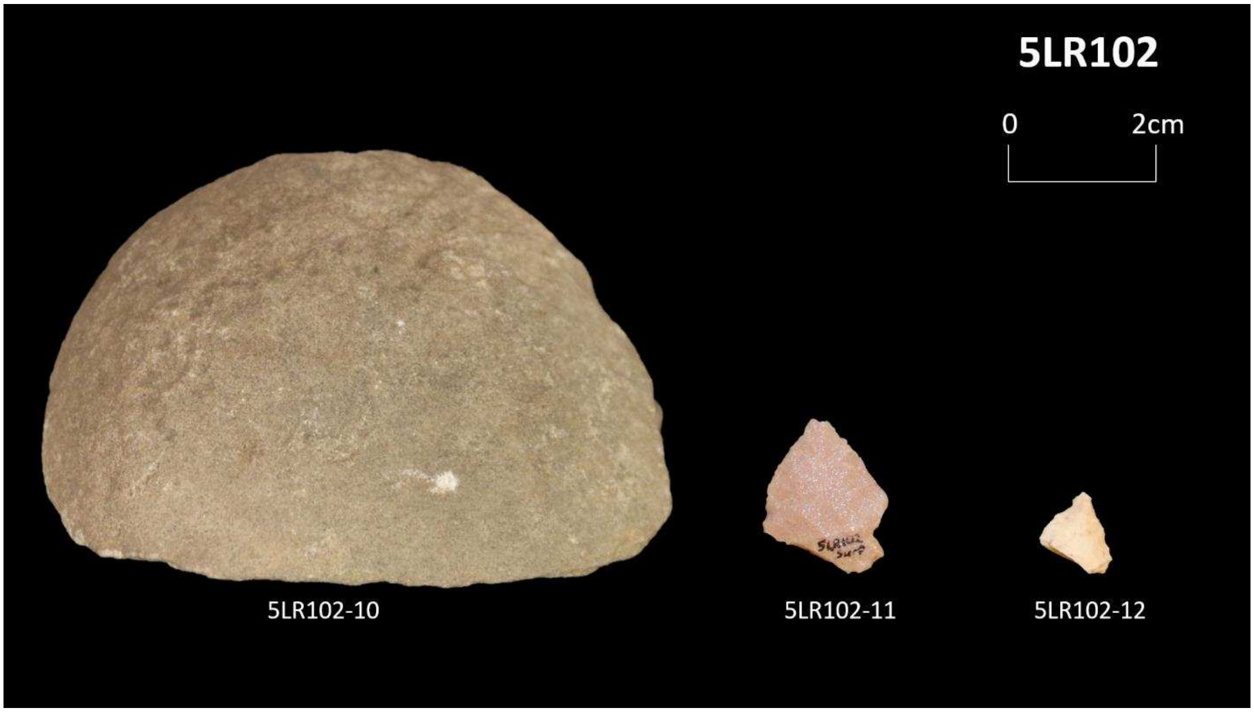
2017 A Persistent Place for Hunter-Gatherers During the Late Holocene: The Case of Burials in Pit on the Coast of Langara Bay, Argentine Patagonia. *The Journal of Island and Coastal Archaeology* 13(3):438-449.

Zvelebil, Mark, Stanton W. Green, and Mark G. Macklin

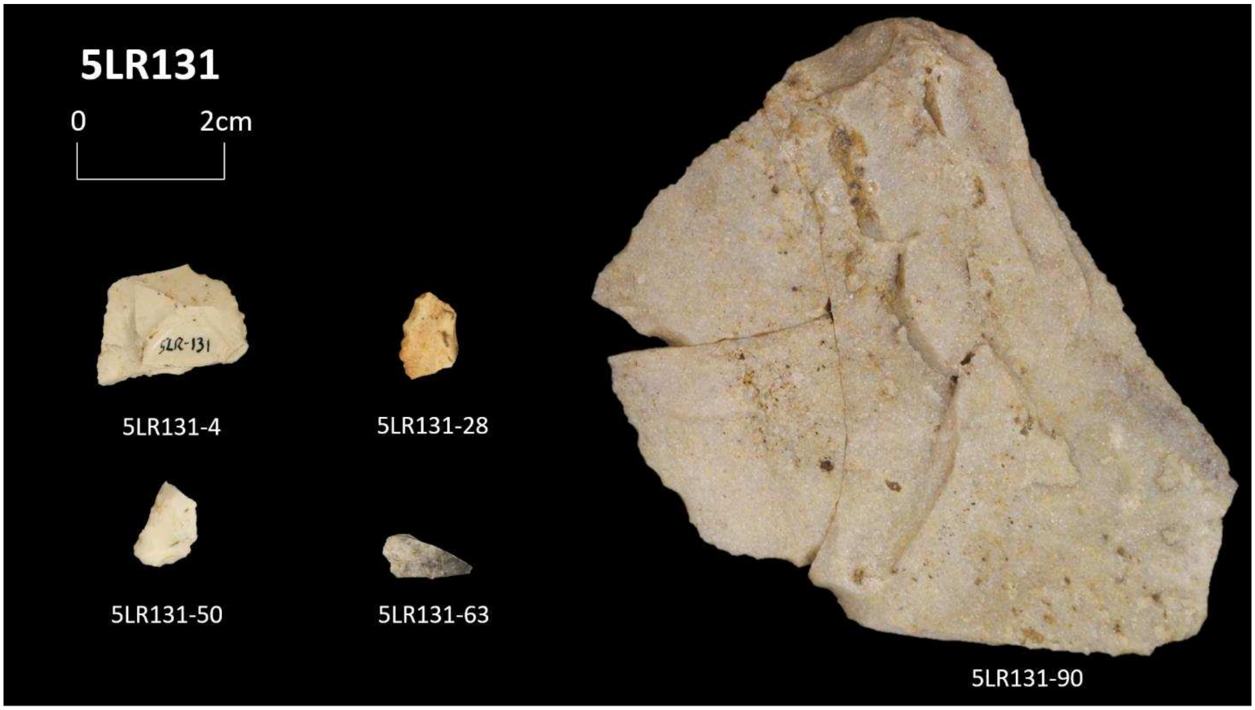
1992 Archaeological Landscapes, Lithic Scatters, and Human Behavior. In *Space, Time, and Archaeological Landscapes*, edited by Jacqueline Rossignol and LuAnn Wandsnider, pp. 193-226. Plenum Press, New York.

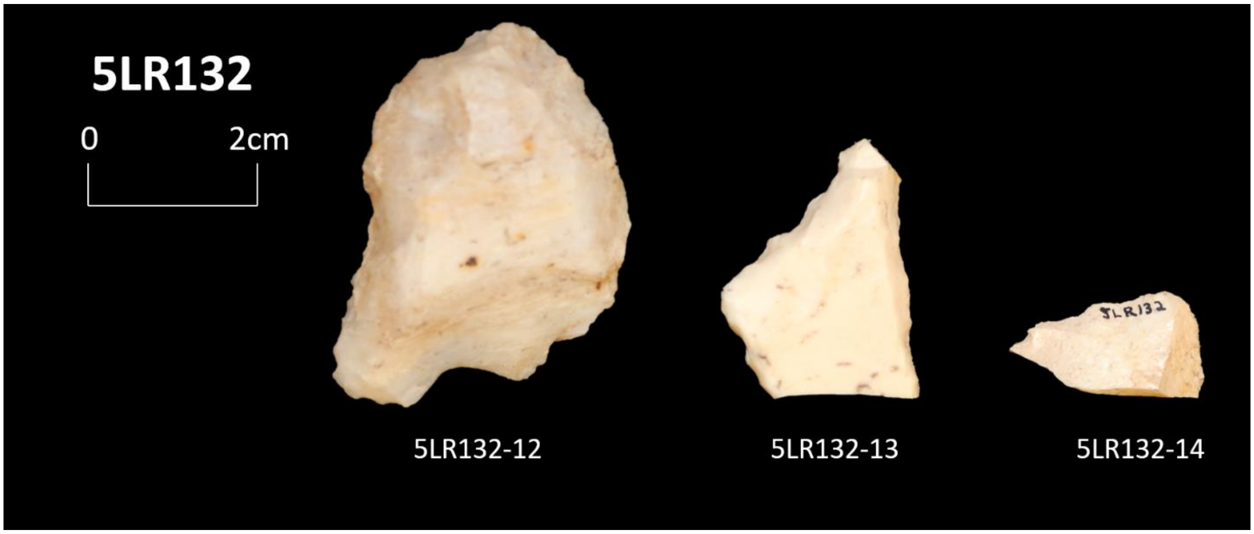
APPENDIX A: PHOTOGRAPHS OF TOOLS BY SITE

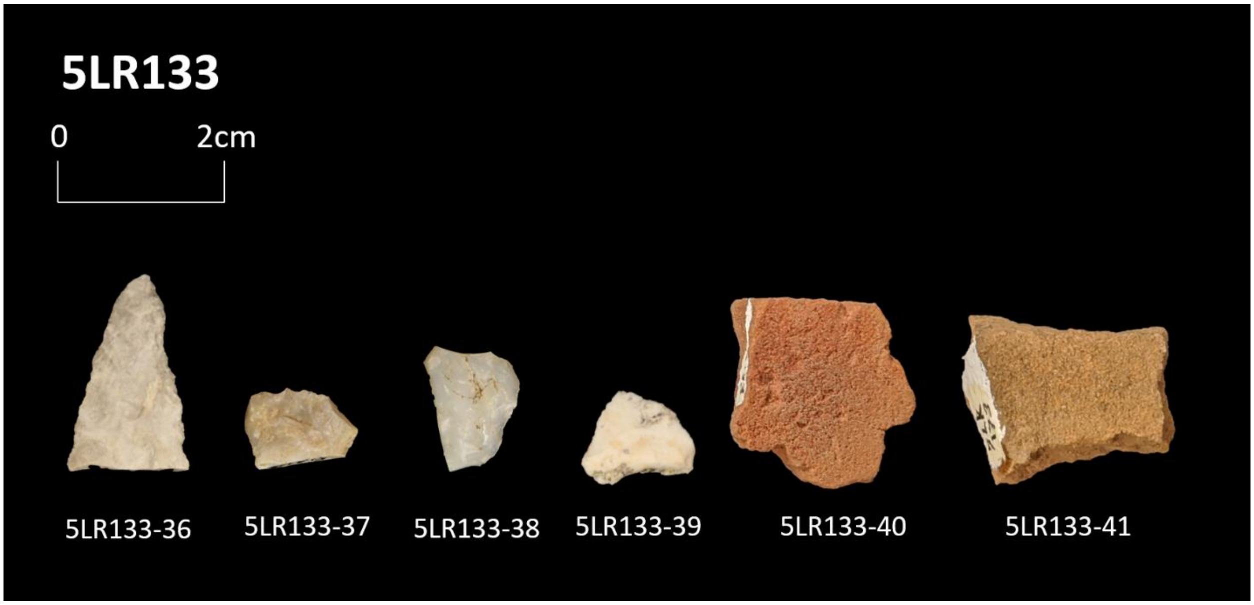

5LR101
0
2cm
5-LR-101
5LR101
5LR101-12
5LR101-13
5LR101-14
5LR101-15
5LR101-16

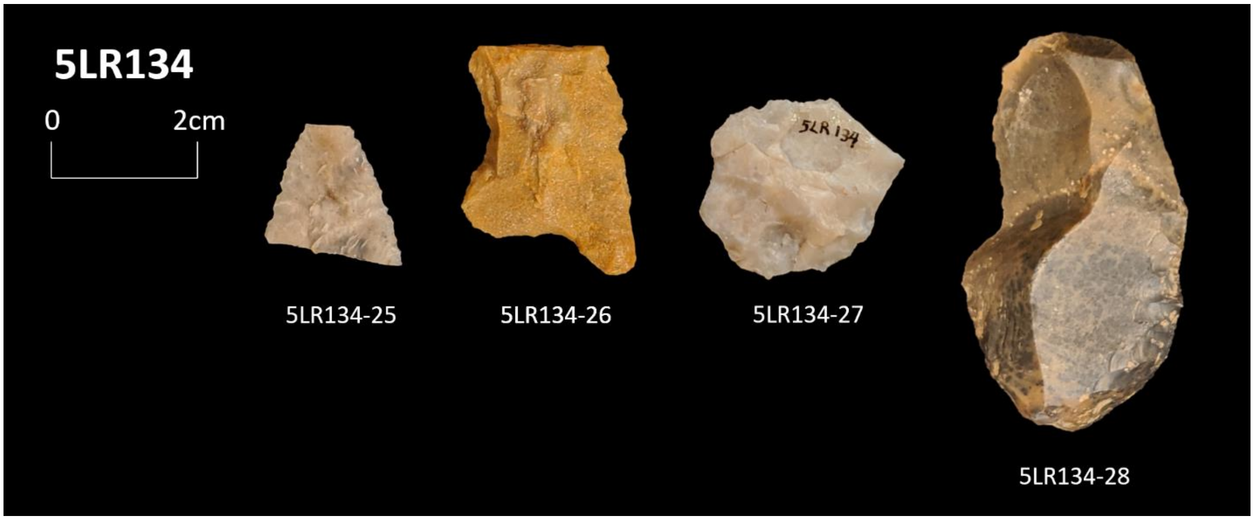

5LR102
0
2cm
5LR102-10
5LR102-11
5LR102-12

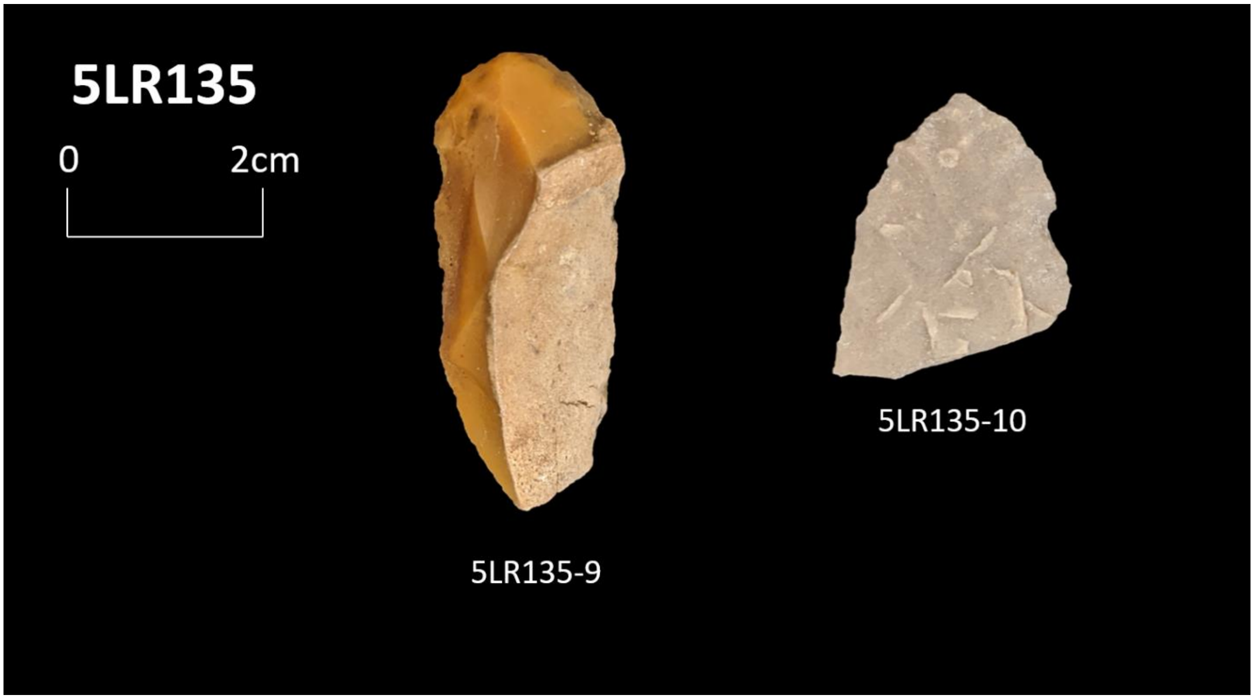

5LR113
0
2cm
5LR113-24
5LR113-25
5LR113-26

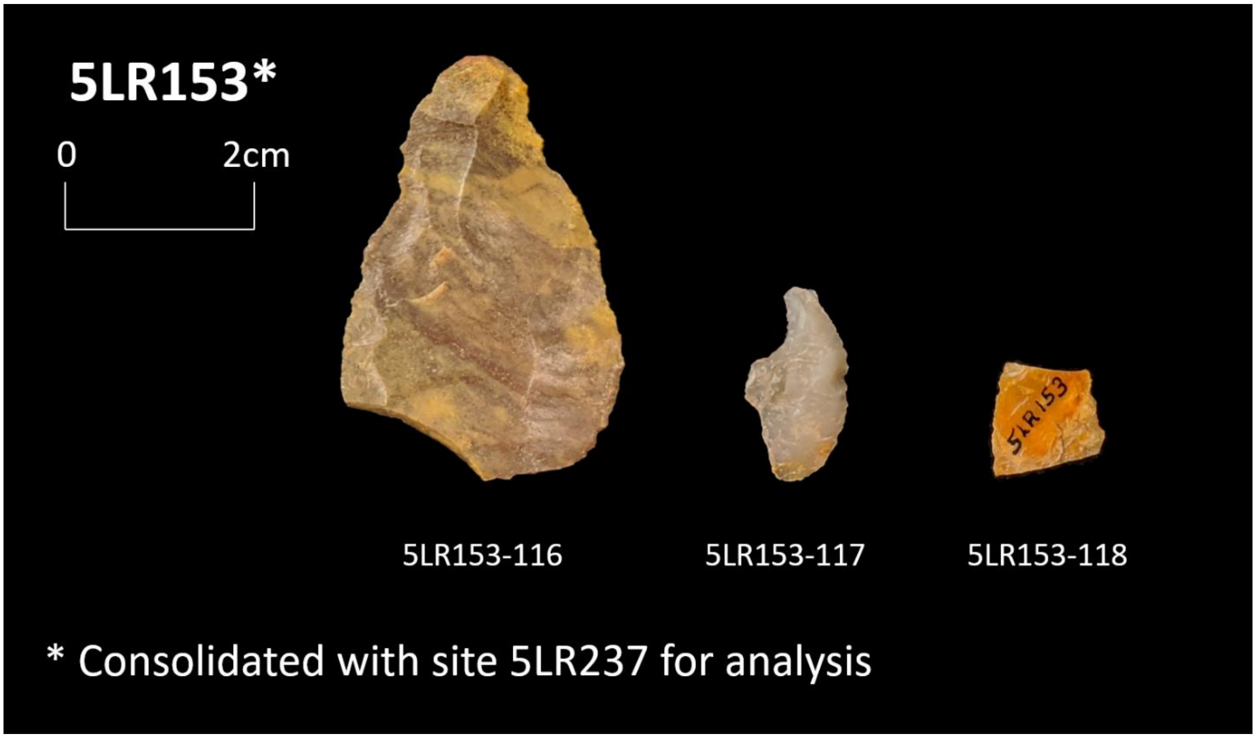

5LR131
0
2cm
5LR-131
5LR131-4
5LR131-28
5LR131-50
5LR131-63
5LR131-90


5LR132
0
2cm
5LR132
5LR132-12
5LR132-13
5LR132-14


5LR133
0
2cm
5LR133-36
5LR133-37
5LR133-38
5LR133-39
5LR133-40
5LR133-41


5LR134
0
2cm
5LR134
5LR134-25
5LR134-26
5LR134-27
5LR134-28





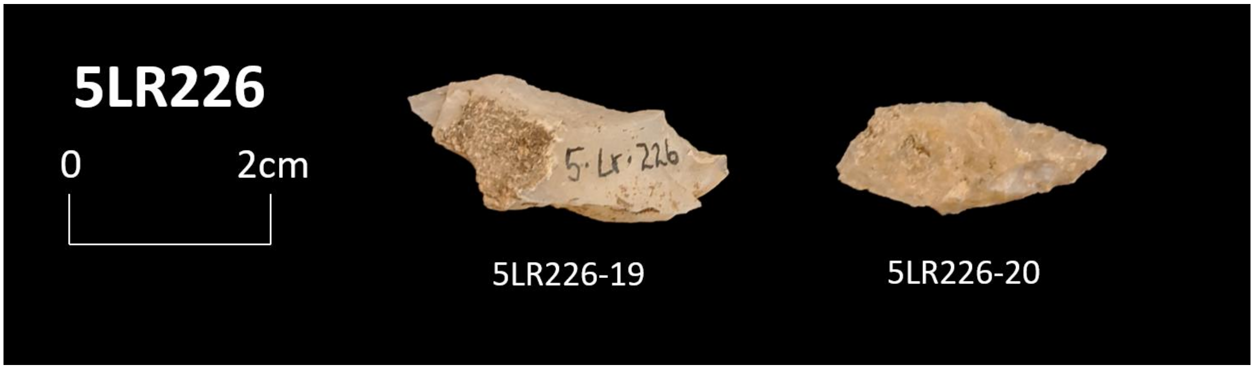
* Consolidated with site 5LR237 for analysis

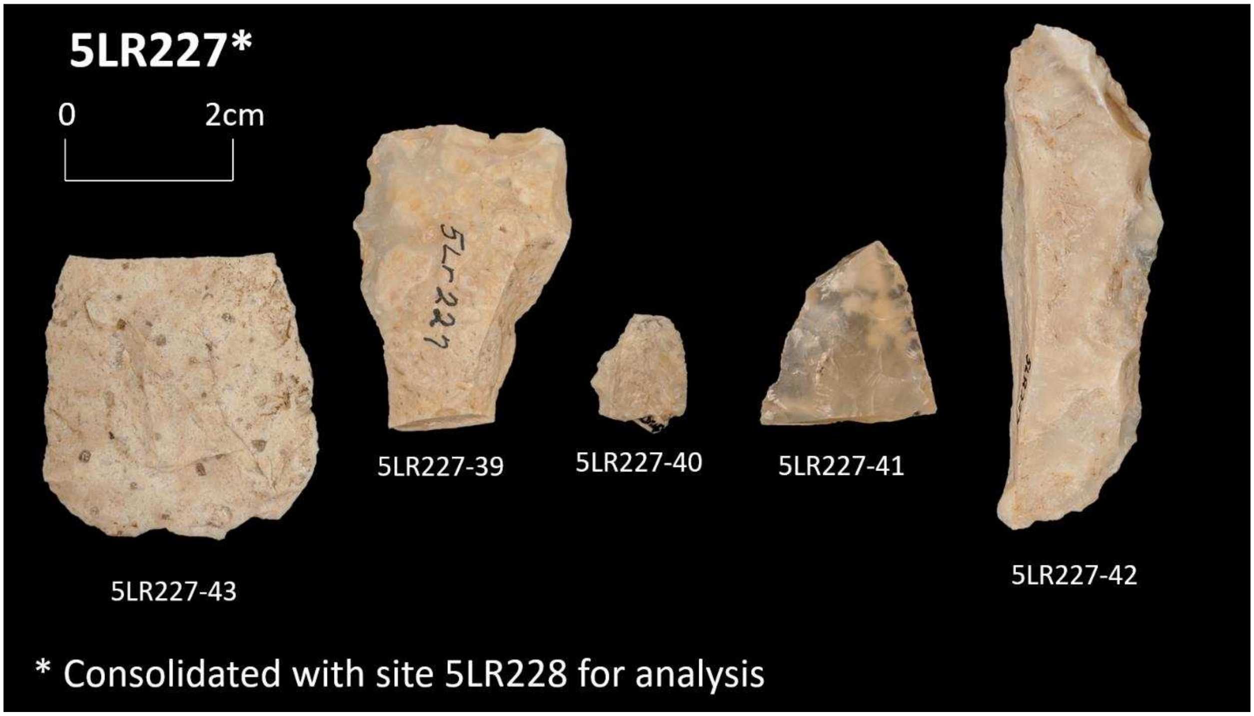

5LR158
0
2cm
5LR158-74
5LR158-75
5LR158-76


5LR174
0
2cm
5LR174-147
5LR174-148
5LR174-149
5LR174-152
5LR174-150
5LR174-151
5LR174-153
5LR174-146
5LR174-154
5LR174-155
5LR174-156
5LR174-157
5LR174-158
5LR174-2019-1

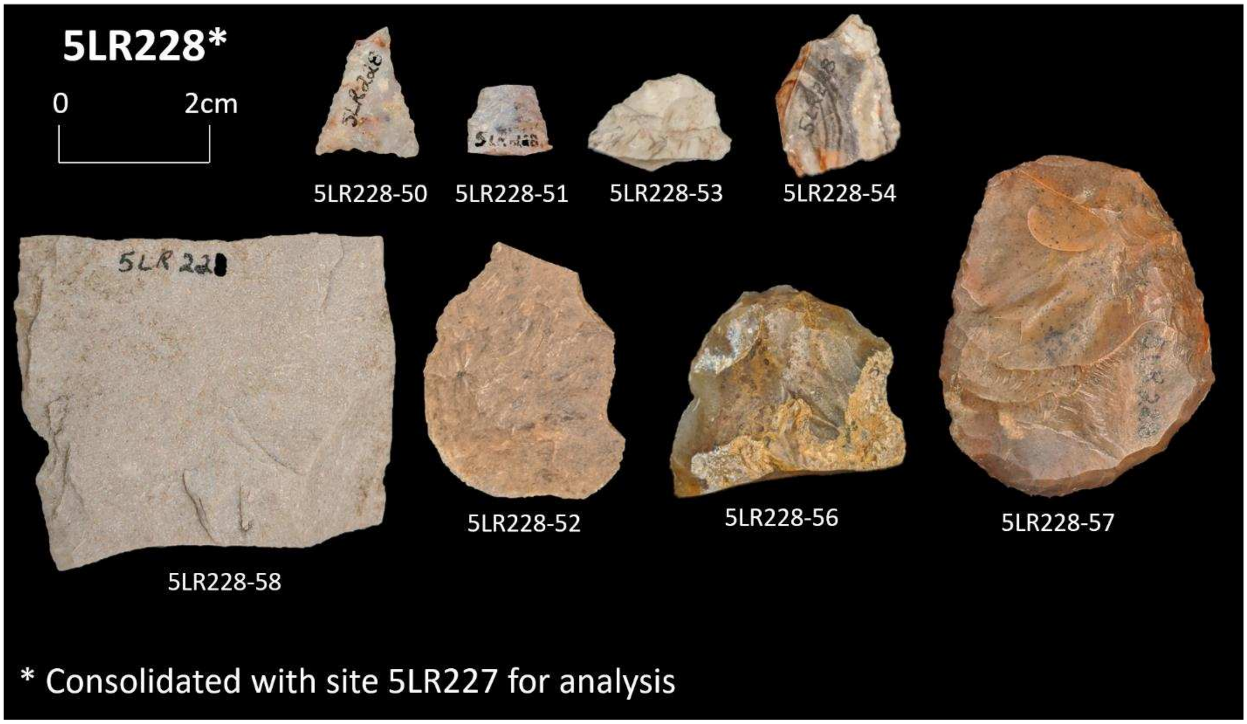

5LR224
0
2cm
5LR224-1


5LR225
0
2cm
5LR225-21
5LR225-22
5LR225-23

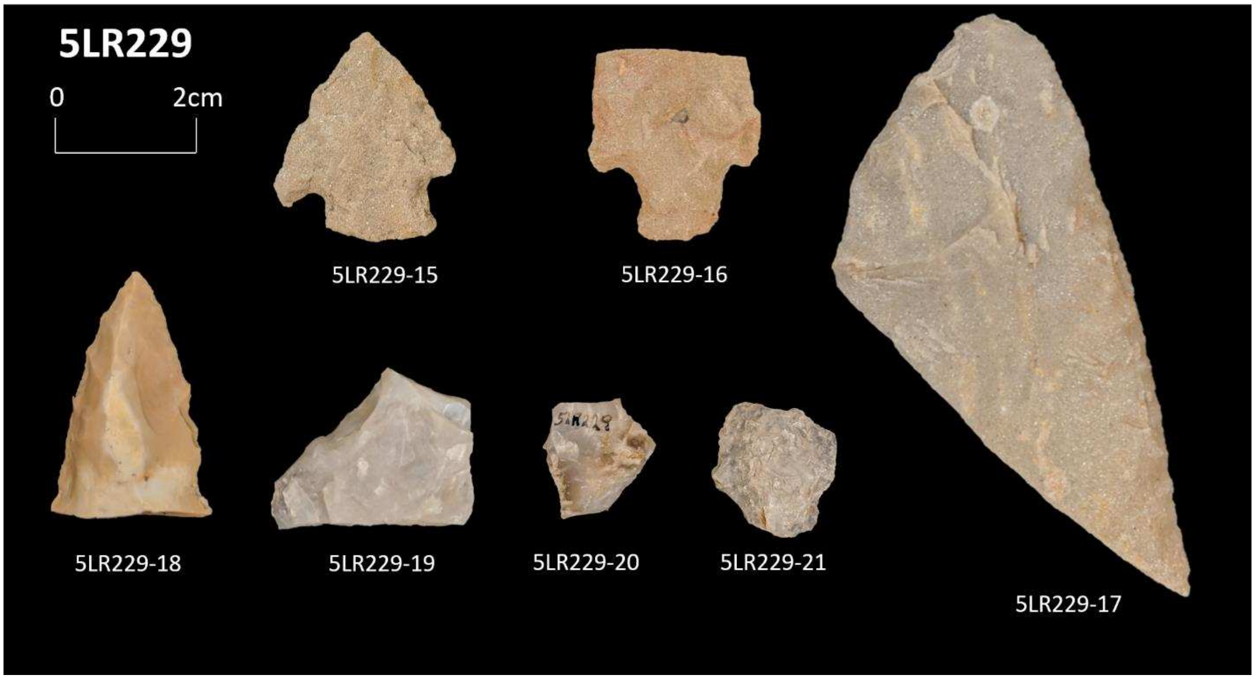

5LR226
0
2cm
5·Lr·226
5LR226-19
5LR226-20



* Consolidated with site 5LR228 for analysis

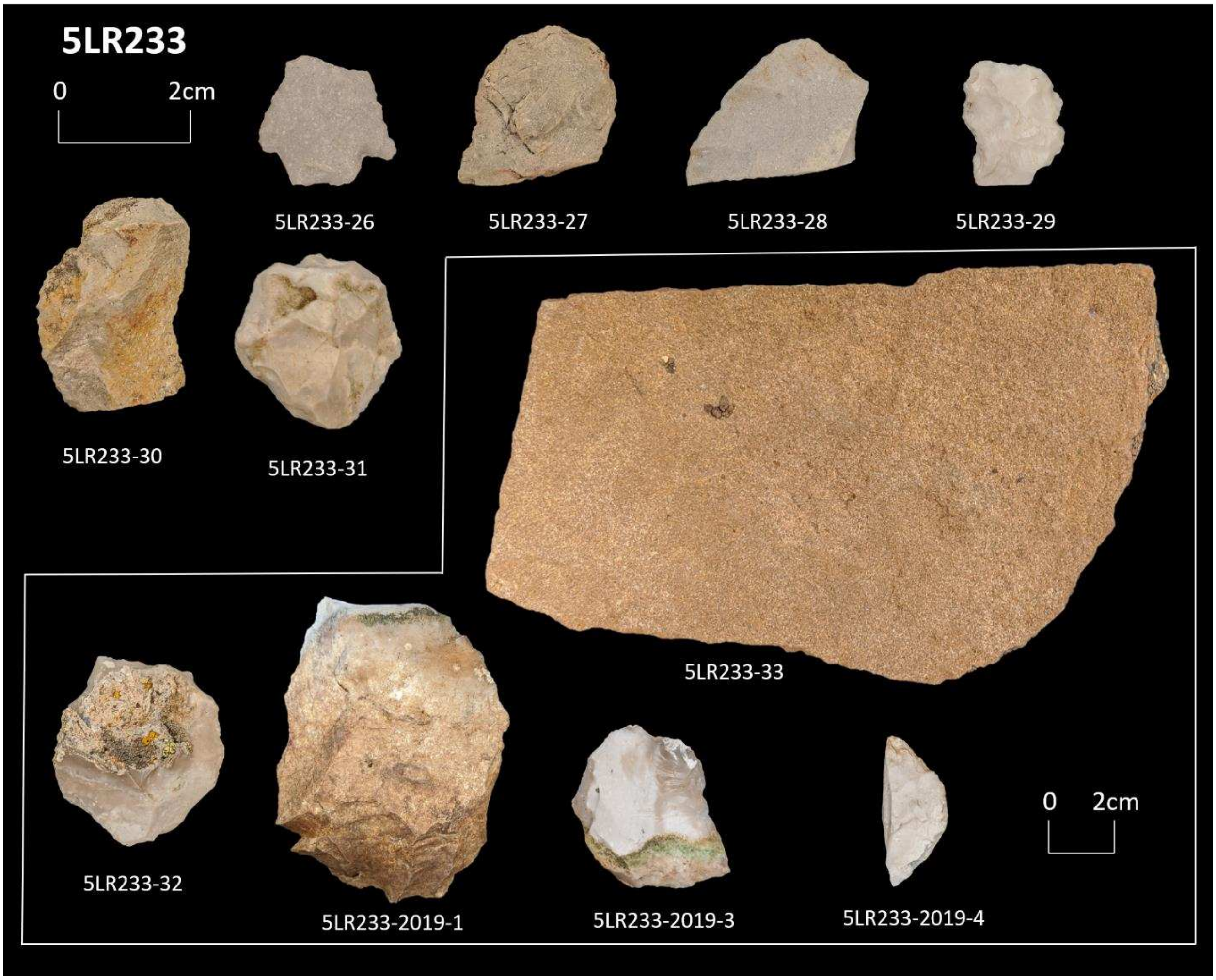


* Consolidated with site 5LR227 for analysis

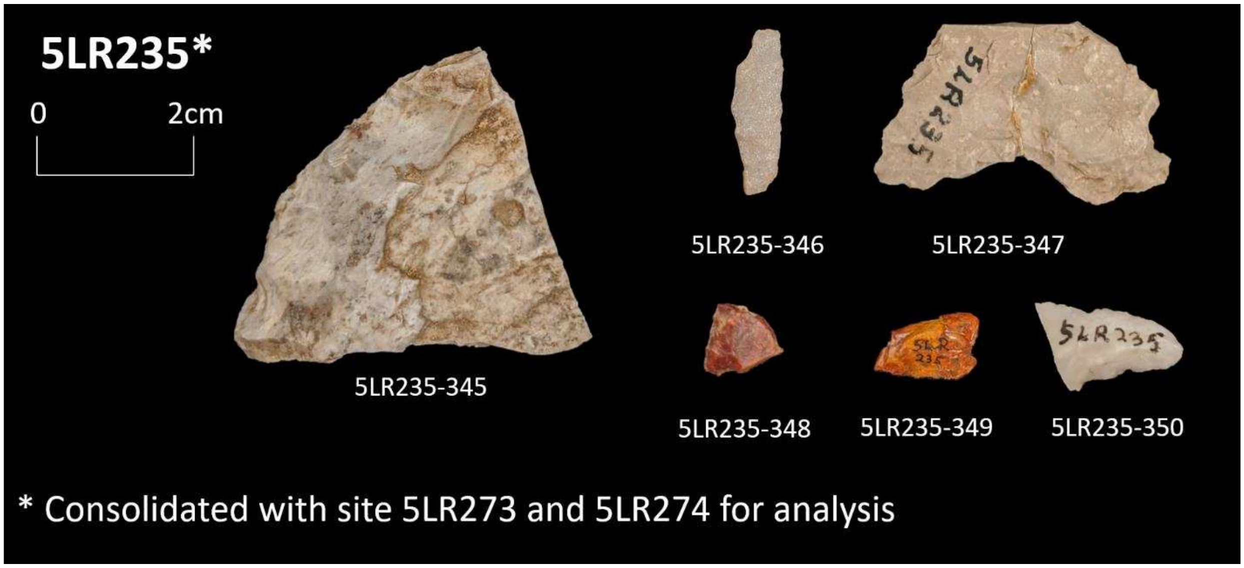

5LR229
0
2cm
5LR229-15
5LR229-16
5LR229-18
5LR229-19
5LR229-20
5LR229-21
5LR229-17


5LR231
0
2cm
5LR231-35
5LR231-36
5LR231-37
5LR231-38


5LR232
0
2cm
5LR232-51
5LR232-52
5LR232-53
5LR232-54


5LR233
0
2cm
5LR233-26
5LR233-27
5LR233-28
5LR233-29
5LR233-30
5LR233-31
5LR233-33
5LR233-32
5LR233-2019-1
5LR233-2019-3
5LR233-2019-4
0
2cm

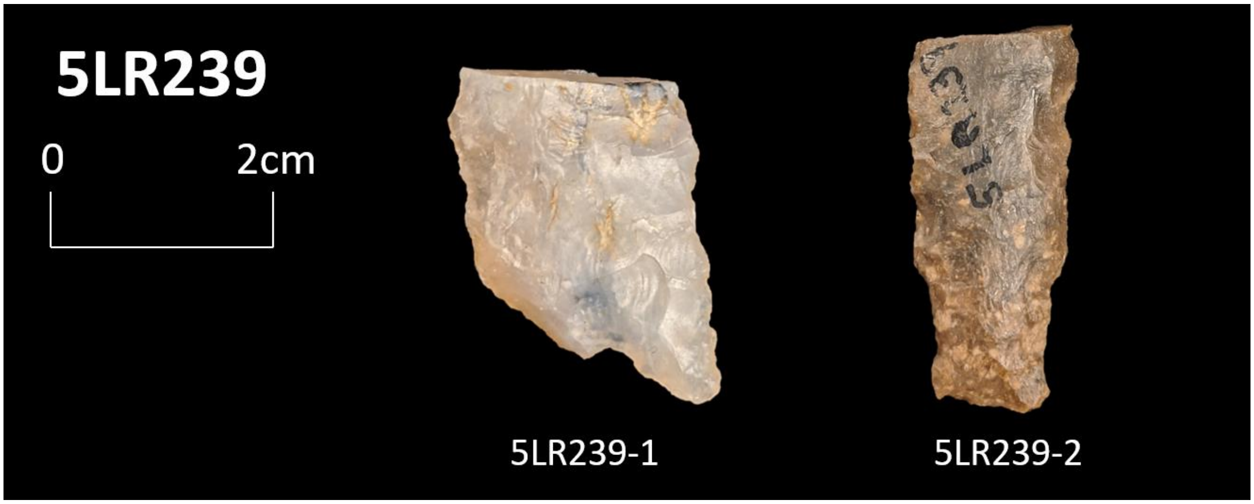

5LR234
0
2cm
5LR234
5LR234-80
5LR234-81
5LR234-82
5LR234-83

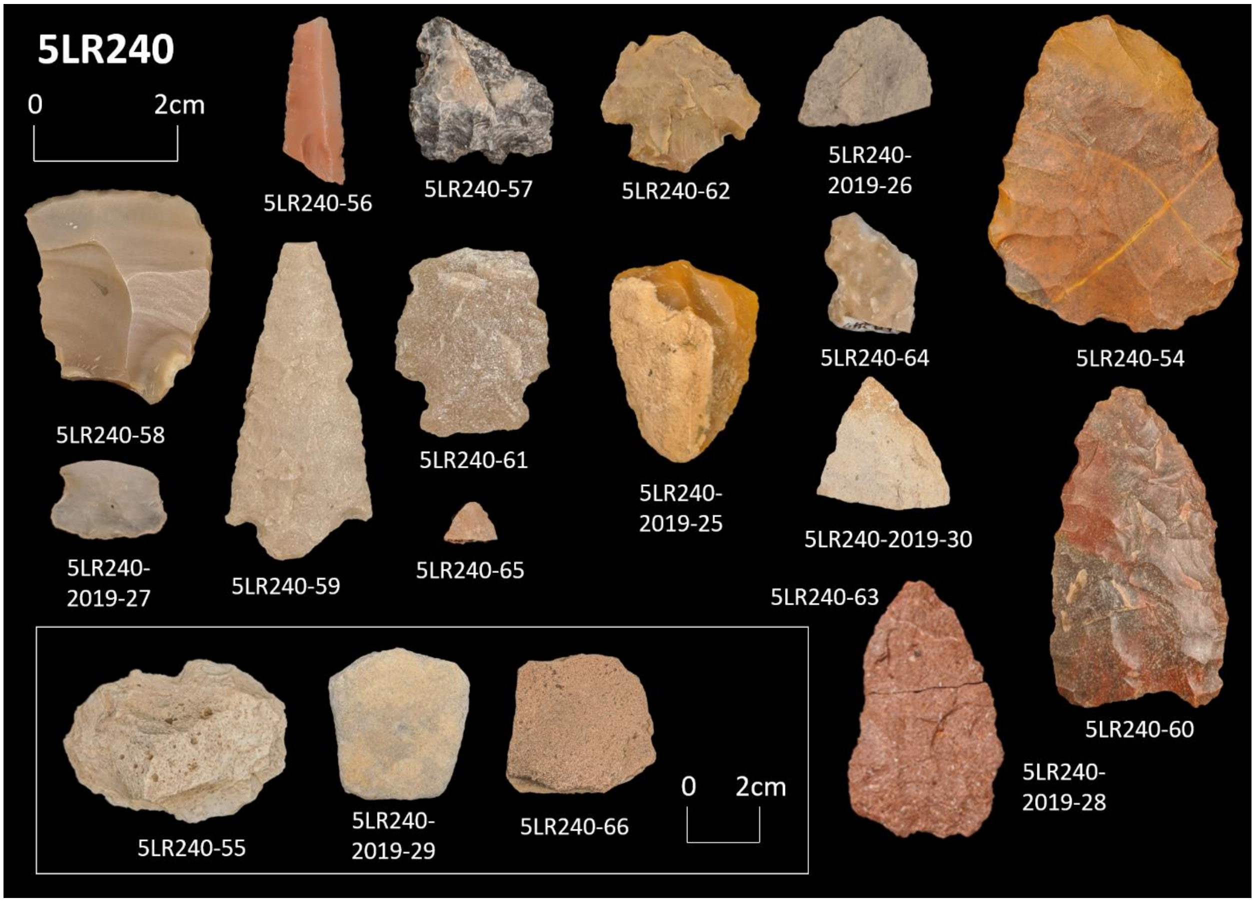


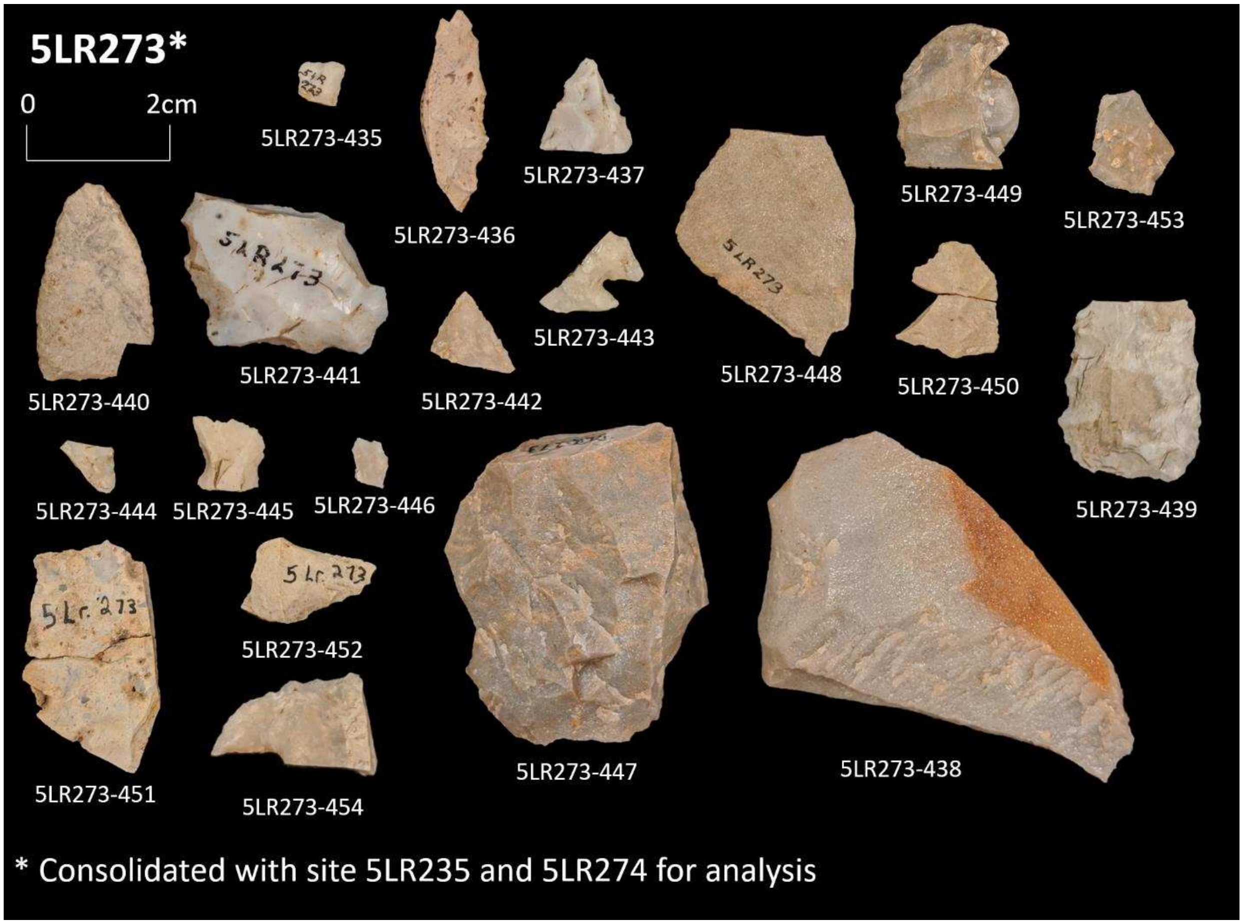
* Consolidated with site 5LR273 and 5LR274 for analysis


5LR237*
0
2cm
5LR237-163
5LR237-164
5LR237-165
5LR237-166
5LR237-167
5LR237-168
5LR237-169
5LR237-170
5LR237-171
5LR237-172
5LR237-173
5LR237-174
5LR237-175
5LR237-176
5LR237-177
5LR237-178
5LR237-180
5LR237-181
5LR237-179
5LR153/237-2019-1
5LR153/237-2019-97
5LR153/237-2019-98
5LR153/237-2019-99
5LR153/237-2019-100
5LR153/237-2019-101
5LR153/237-2019-102
* Consolidated with site 5LR153 for analysis


5LR238
0
2cm
5LR238-143
5LR238-144
5LR238-145
5LR238-146
5LR238-147
5LR238-148


5LR239
0
2cm
5LR239-1
5LR239-2


5LR240
0
2cm
5LR240-56
5LR240-57
5LR240-62
5LR240-2019-26
5LR240-58
5LR240-64
5LR240-54
5LR240-61
5LR240-2019-25
5LR240-2019-30
5LR240-2019-27
5LR240-59
5LR240-65
5LR240-63
5LR240-60
5LR240-55
5LR240-2019-29
5LR240-66
0
2cm
5LR240-2019-28


5LR273*
0
2cm
5LR273-435
5LR273-436
5LR273-437
5LR273-449
5LR273-453
5LR273-440
5LR273-441
5LR273-443
5LR273-442
5LR273-448
5LR273-450
5LR273-439
5LR273-444
5LR273-445
5LR273-446
5LR273-451
5LR273-452
5LR273-454
5LR273-447
5LR273-438
* Consolidated with site 5LR235 and 5LR274 for analysis


5LR274*
0
2cm
5LR274-30
5LR274-31
5LR274-32
5LR274-33
* Consolidated with site 5LR235 and 5LR273 for analysis


5LR1733
0
2cm
5LR1733-1


5LR1834
0
2cm
5LR1834-23


5LR14335
0
2cm
5LR14335-1


5LR14336
0
2cm
5LR14336-1

APPENDIX B: ASSEMBLAGE COMPOSITION BY SITE

DEBITAGE BY INDIVIDUAL SITE PRIOR TO 2019

Key: Flake (FK), angular debris (ANG), crypto-crystalline silicate (CCS), quartzite (QTZ), quartz (QZ), obsidian (OBS), yes (Y), no (N)
* Obsidian flakes (n = 4) were removed for sourcing analysis and attribute data was not collected

		Artifact Element (n)		***Size Class (n)***						***Thermally Altered (n)***		***Cortex (n)***		***Striking Platform (n)***		***Lithic Raw Material (n)***			
Site	***Total Quantity (n)***	**FK**	**ANG**	**1**	**2**	**3**	**4**	**5**	**6**	**Y**	**N**	**Y**	**N**	**Y**	**N**	**CCS**	**QTZ**	**QZ**	**OBS***
5LR101	11	8	3	1	7	2	1	0	0	1	10	5	6	3	8	11	0	0	0
5LR102	9	6	3	2	2	4	0	0	1	2	7	4	5	5	4	9	0	0	0
5LR113	23	22	1	7	15	1	0	0	0	2	21	0	23	10	13	5	18	0	0
5LR114	10	10	0	2	5	3	0	0	0	1	9	0	10	2	8	4	6	0	0
5LR131	86	79	7	43	37	3	3	0	0	4	82	1	85	24	62	58	28	0	0
5LR132	111	105	6	90	19	2	0	0	0	5	106	2	109	16	95	109	2	0	0
5LR133	35	35	0	9	20	5	1	0	0	4	31	9	26	10	25	35	0	0	0
5LR134	23	19	4	2	10	6	2	2	1	1	22	7	16	6	17	20	2	1	0
5LR135	8	8	0	1	4	2	0	1	0	**0**	8	1	7	2	6	6	2	0	0
5LR153	115	109	6	17	81	16	1	0	0	11	104	14	101	20	95	113	2	0	0
5LR158	73	70	3	19	36	13	5	0	0	10	63	14	59	21	52	69	3	1	0
5LR173	3	3	0	1	2	0	0	0	0	**0**	3	1	2	0	3	3	0	0	0
5LR174	147	126	21	30	70	35	6	3	0	1	143	31	113	41	103	116	7	21	3
5LR225	21	18	3	3	6	6	2	3	0	1	19	7	13	2	18	18	2	0	1
5LR226	18	16	2	0	8	8	0	2	0	1	17	8	10	8	10	18	0	0	0

		Artifact Element (n)		*Size Class (n)*						*Thermally Altered (n)*		*Cortex (n)*		*Striking Platform (n)*		*Lithic Raw Material (n)*			
Site	***Total Quantity (n)***	**FK**	**ANG**	**1**	**2**	**3**	**4**	**5**	**6**	**Y**	**N**	**Y**	**N**	**Y**	**N**	**CCS**	**QTZ**	**QZ**	**OBS***
5LR227	38	30	8	2	15	13	7	1	0	**0**	38	16	22	11	27	36	2	0	0
5LR228	50	46	4	3	23	18	5	1	0	16	34	9	41	13	37	43	7	0	0
5LR229	13	13	0	0	7	3	2	1	0	**0**	13	5	8	0	13	13	0	0	0
5LR231	34	31	3	6	17	7	4	0	0	**0**	34	8	26	12	22	33	1	0	0
5LR232	50	47	3	13	18	9	9	1	0	6	44	10	40	16	33	49	0	1	0
5LR233	25	20	5	2	11	8	4	0	0	2	23	3	22	9	16	21	4	0	0
5LR234	79	75	4	3	31	32	10	2	1	1	78	7	72	37	42	79	0	0	0
5LR235	331	327	4	176	121	30	2	2	0	3	328	27	304	64	267	162	169	0	0
5LR236	44	43	1	3	24	15	2	0	0	2	42	11	33	18	26	35	9	0	0
5LR237	162	157	5	12	84	55	10	1	0	10	152	17	145	56	106	158	1	3	0
5LR238	142	137	5	36	63	25	16	2	0	7	135	18	124	53	89	45	97	0	0
5LR240	53	51	2	10	25	8	9	1	0	5	48	5	48	23	30	41	12	0	0
5LR273	434	421	13	181	206	33	10	4	0	22	412	49	385	160	274	388	46	0	0
5LR274	29	27	2	2	24	2	1	0	0	3	26	0	29	16	13	22	7	0	0
5LR1834	22	21	1	0	8	10	4	0	0	2	20	9	13	9	13	20	2	0	0

TOOLS COLLECTED BY INDIVIDUAL SITE PRIOR TO 2019

Key: FS#: Assigned sequentially by each individual site; **Artifact Class**: Chipped stone (CS); **Artifact Element**: Biface (BF), Scraper (SC), projectile point (PP), handstone (MAN), netherstone (MET), edge modified flake (EMF), core (CORE), drill (DR), preform (PRE), uniface (UN), graver (GR); **Portion**: Complete (C), near complete (NC), undetermined fragment (F), distal fragment (FD), proximal fragment (FP), medial fragment (FM), lateral fragment (FL); **Other**: Measurement based on incomplete artifact (*), not applicable (-), not available (n/a)

Site #	FS #	Artifact Class	Artifact Element	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Thermally Altered (Y/N)	PP: Neck Width (mm)	PP: Base Width (mm)	Typological Classification	Lithic Material Type	Portion
5LR17	1	CS	EMF	38.1	33.9	8.6	9.9	N	-	-	-	Quartzite	FP
5LR17	2	CS	SC	48.3	38.7	10.3	23.2	Y	-	-	-	Chert (CCS)	FD
5LR17	3	CS	EMF	59.3	37.2	14.3	35.4	N	-	-	-	Chert (CCS)	C
5LR17	4	CS	DR	43	22.3	5.9	3.8	N	-	-	-	Chert (CCS)	C
5LR17	5	CS	EMF	127.1	64.8	14.1	121.2	N	-	-	-	Quartzite	C
5LR17	6	GS	MET	159.3	105.4	25.7	625	Y	-	-	-	Sandstone	F
5LR101	12	CS	BF	15.4	20.1	6.4	3.3	Y	-	-	-	Chert (CCS)	FM
5LR101	13	CS	PP	13.8	16.6	4	1.1	Y	-	-	Unassigned	Chert (CCS)	FD
5LR101	14	CS	BF	27.7	32.1	8.7	8.1	N	-	-	-	Chert (CCS)	FD
5LR101	15	CS	SC	36.9	27.4	5.2	6.7	N	-	-	-	Chert (CCS)	C
5LR101	16	CS	CORE	28.5	21.8	11.8	10.2	N	-	-	-	Quartz	C
5LR102	10	GS	MAN	59.7	78.3	28.3	148.5	N	-	-	-	Sandstone	F
5LR102	11	CS	PP	21.1	17.2	3.1	1.2	N	10.5*	n/a	Pelican Lake	Quartzite	F
5LR102	12	CS	PP	11.2	11.3	3.3	0.3	N	-	-	Unassigned	Chert (CCS)	FD
5LR113	24	CS	BF	41.9	64.7	13.9	37.4	Y	-	-	-	Quartzite	FP
5LR113	25	CS	BF	30.1	47.4	7.5	15.5	Y	-	-	-	Quartzite	F
5LR113	26	CS	EMF	37.5	37.6	8	13.1	N	-	-	-	Quartzite	F
5LR131	4	CS	EMF	16.7	25	4.8	2.5	N	-	-	-	Chert (CCS)	FP
5LR131	28	CS	PP	12	7.9	3.2	0.3	Y	-	-	Unassigned	Chert (CCS)	FD
5LR131	50	CS	PP	11.8	7.7	3.5	0.3	N	-	-	Unassigned	Chert (CCS)	FD
5LR131	63	CS	UN	6.3	13.2	2.4	0.2	N	-	-	-	Chert (CCS)	FM
5LR131	90	CS	BF	87.1	100.9	10.3	85.6	N	-	-	-	Quartzite	C
5LR132	112	CS	BF	45	32	14.5	27.4	N	-	-	-	Chert (CCS)	C
5LR132	113	CS	BF	30.8	18.7	4.3	1.9	N	-	-	-	Chert (CCS)	FL
5LR132	114	CS	BF	12.8	26.6	5.7	1.7	N	-	-	-	Chert (CCS)	FL

Site #	FS #	Artifact Class	Artifact Element	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Thermally Altered (Y/N)	PP: Neck Width (mm)	PP: Base Width (mm)	Typological Classification	Lithic Material Type	Portion
5LR133	36	CS	PP	23.8	14.6	4.2	1.3	N	-	-	Unassigned	Chert (CCS)	FD
5LR133	37	CS	BF	19.9	13	6.4	1.9	N	-	-	-	Chalcedony (CCS)	FM
5LR133	38	CS	PRE	15.2	10.1	3.1	0.5	N	-	-	-	Chalcedony (CCS)	FM
5LR133	39	CS	BF	11.4	15.1	3.1	0.6	N	-	-	-	Chert (CCS)	F
5LR133	40	GS	MET	23.2	21.1	10.1	7.1	Y	-	-	-	Sandstone	F
5LR133	41	GS	MET	20.5	17.2	8.6	3.9	N	-	-	-	Sandstone	F
5LR134	22	CS	BF	12.8	37.4	11	5.7	N	-	-	-	Chert (CCS)	FP
5LR134	25	CS	PP	19.6	20.9	3.5	1.3	N	-	-	Unassigned Paleoindian / Archaic	Chalcedony (CCS)	FM
5LR134	26	CS	PP	31.8	23.1	5.2	4.8	N	-	-	James Allen	Quartzite	FL / FP
5LR134	27	CS	BF	29.1	25.9	7	4.7	N	-	-	-	Chert (CCS)	F
5LR134	28	CS	SC	55	29.7	10.7	17.2	N	-	-	-	Chert (CCS)	C
5LR135	9	CS	SC	47.1	18.7	12	10.2	N	-	-	-	Chert (CCS)	C
5LR135	10	CS	BF	29.4	25.7	3.7	4.7	N	-	-	-	Quartzite	FD
5LR153	116	CS	EMF	45.2	29.7	4.3	6.4	Y	-	-	-	Chert (CCS)	F
5LR153	117	CS	BF	20.7	10.4	3.6	0.7	N	-	-	-	Chalcedony (CCS)	F
5LR153	118	CS	BF	13.2	13	3.2	0.8	-	-	-	-	Chert (CCS)	FL
5LR153	116	CS	EMF	45.2	29.7	4.3	6.4	Y	-	-	-	Chert (CCS)	F
5LR158	74	CS	BF	22.4	32.8	11.8	8.4	Y	-	-	-	Chalcedony (CCS)	FD
5LR158	75	CS	SC	25	27.4	5.4	4.7	N	-	-	-	Chert (CCS)	C
5LR158	76	CS	PP	12.2	12.4	3.8	0.6	N	7.8*	8.4*	Hogback Corner-notched	Chert (CCS)	FP
5LR174	146	CS	CORE	57.7	41.9	33.8	98.7	N	-	-	-	Chert (CCS)	F
5LR174	147	CS	PP	16.3	25.5	5.6	2.2	N	16.7	n/a	Unassigned Archaic	Chalcedony (CCS)	F
5LR174	148	CS	PP	17.4	11.1	2.5	0.6	N	7.5	11.3	Plains Tri-Notched	Chalcedony (CCS)	NC
5LR174	149	CS	PP	13.2	13.6	2.2	0.4	N	-	13.6	Unnotched Triangular Point	Chalcedony (CCS)	FP
5LR174	150	CS	PP	31.4	22.6	6.6	6.5	N	-	12.5	Scottsbluff	Chert (CCS)	FP
5LR174	151	CS	PP	33.8	20.5	5.8	4.2	N	12.2	12.9	Unassigned Late Paleoindian	Chert (CCS)	NC

Site #	FS #	Artifact Class	Artifact Element	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Thermally Altered (Y/N)	PP: Neck Width (mm)	PP: Base Width (mm)	Typological Classification	Lithic Material Type	Portion
5LR174	152	CS	EMF	55.6	18.1	9.8	9.9	Y	-	-	-	Chert (CCS)	C
5LR174	153	CS	SC	38.1	28	14.1	11.7	N	-	-	-	Chert (CCS)	F
5LR174	154	CS	PRE	25.1	11	3.9	1.7	Y	-	-	-	Chert (CCS)	FL
5LR174	155	CS	PP	18.3	14.5	4.2	1.4	N	11.8	13.9	Unassigned Archaic	Chert (CCS)	FP
5LR174	156	CS	SC	28.6	27.3	5.7	4.7	Y	-	-	-	Chert (CCS)	F
5LR174	157	CS	SC	45	21.3	5.9	5.1	N	-	-	-	Quartzite	F
5LR174	158	CS	PP	31.1	23.1	5.6	4.7	N	14.7	*15.5	Mount Albion	Quartzite	F
5LR224	1	CS	PRE	26.1	18.5	3.6	2.9	N	-	15		Quartzite	FP
5LR225	21	CS	DR	10.2	11.8	2.3	0.3	N	-	-	-	Chalcedony (CCS)	FM
5LR225	22	CS	PRE	27.9	20.3	3.9	2.7	Y	-	-	-	Quartzite	C
5LR225	23	CS	DR	26	11.4	5.8	1.8	N	-	-	-	Obsidian	FP
5LR226	19	CS	BF	32.1	14.5	9.7	3.5	N	-	-	-	Chalcedony (CCS)	FL
5LR226	20	CS	EMF	24.9	10.3	2.3	0.6	Y	-	-	-	Chert (CCS)	C
5LR227	39	CS	BF	36.5	25.8	9.3	10.3	N	-	-	-	Chert (CCS)	F
5LR227	40	CS	PP	14.5	12.7	3	0.7	N	-	-	Unassigned Late Prehistoric	Chert (CCS)	F
5LR227	41	CS	BF	22.2	21.6	5.9	2.7	N	-	-	-	Chert (CCS)	F
5LR227	42	CS	BF	60.5	20	14.8	15.8	N	-	-	-	Chert (CCS)	F
5LR227	43	CS	PRE	34.5	34.5	6.8	9.7	N	-	-	-	Chert (CCS)	F
5LR228	50	CS	PP	17.8	14.1	2.4	0.6	N	n/a	14.1	Unnotched Triangular Point	Chert (CCS)	C
5LR228	51	CS	PP	9.6	10.9	2.6	0.4	N	n/a	n/a	Unassigned late prehistoric	Chalcedony (CCS)	FM
5LR228	52	CS	UN	34.3	28.6	5.2	5.9	Y	-	-	-	Chert (CCS)	C
5LR228	53	CS	BF	13.2	21.5	6.8	1.1	N	-	-	-	Chert (CCS)	FD
5LR228	54	CS	BF	21.9	19	6	3.5	Y	-	-	-	Chert (CCS)	FL
5LR228	56	CS	SC	28.5	35.7	9.4	11.6	Y	-	-	-	Chert (CCS)	FD
5LR228	57	CS	SC	45.9	37.5	7.6	18.7	Y	-	-	-	Chert (CCS)	C
5LR228	58	CS	EMF	45.2	54.3	10.7	42.1	N	-	-	-	Quartzite	FM
5LR229	17	CS	BF	83	38.1	9	24.6	N	-	-	-	Quartzite	FL

Site #	FS #	Artifact Class	Artifact Element	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Thermally Altered (Y/N)	PP: Neck Width (mm)	PP: Base Width (mm)	Typological Classification	Lithic Material Type	Portion
5LR229	20	CS	BF	17.7	15.7	5	1.4	N	-	-	-	Chalcedony (CCS)	F
5LR229	14	CS	EMF	30.2	21.1	4.5	2.8	N	-	-	-	Chert (CCS)	FL
5LR229	21	CS	PRE	19.4	16.4	3.8	1.2	N	-	-	-	Chalcedony (CCS)	F
5LR229	18	CS	SC	35.3	23.1	9.3	7.3	N	-	-	-	Chert (CCS)	FD
5LR229	19	CS	UN	23.2	18.3	6.8	2.6	N	-	-	-	Chalcedony (CCS)	FL
5LR229	16	CS	PP	27.5	24.3	6	5	Y	13.1	12	Mount Albion	Quartzite	FP
5LR229	15	CS	PP	30.2	26.1	4.5	3.2	N	14.5	16	Pelican Lake	Quartzite	F
5LR231	37	CS	BF	13.3	9.5	3.5	0.4	N	-	-	-	Chert (CCS)	FL
5LR231	36	CS	EMF	34.2	22.8	10	10.7	Y	-	-	-	Chert (CCS)	F
5LR231	35	CS	SC	26.8	23.8	7	3.6	N	-	-	-	Chert (CCS)	C
5LR231	38	CS	PP	20.5	16.1	3.8	1.1	Y	-	-	Unassigned	Chert (CCS)	FP
5LR232	51	CS	BF	37.1	44	14.1	22.4	Y	-	-	-	Chalcedony (CCS)	FL
5LR232	52	CS	BF	30.4	35.3	10	12	Y	-	-	-	Chert (CCS)	FL
5LR232	53	CS	BF	29.1	18.7	5	3.6	N	-	-	-	Chert (CCS)	FL
5LR232	54	CS	SC	14.1	12.7	4	1	N	-	-	-	Chert (CCS)	FL
5LR233	28	CS	BF	22.6	27.8	5.9	4.7	N	-	-	-	Quartzite	FD
5LR233	29	CS	BF	19.2	16.6	3.6	1.6	N	-	-	-	Chert (CCS)	FP
5LR233	32	CS	CORE	58	50.7	18.2	54.6	N	-	-	-	Chert (CCS)	C
5LR233	30	CS	EMF	32.9	22.2	8.8	7.9	N	-	-	-	Quartzite	C
5LR233	31	CS	EMF	27	25.7	9.7	6.9	N	-	-	-	Chert (CCS)	C
5LR233	33	GS	MET	128.6	77	36	638	N	-	-	-	Sandstone	FL
5LR233	27	CS	PRE	24.6	22	7.4	4.7	Y	-	-	-	Quartzite	FP
5LR233	26	CS	PP	20	23.1	3.4	2.1	N	13.8	11.1	Pelican Lake	Quartzite	FP
5LR234	81	CS	BF	21.2	28	8.6	4.7	N	-	-	-	Chert (CCS)	FD
5LR234	82	CS	PRE	37.5	22.1	6.2	7.1	N	-	-	-	Chalcedony (CCS)	C
5LR234	83	CS	PRE	16.3	16.7	3.3	1.2	N	-	-	-	Chert (CCS)	FP
5LR234	80	CS	SC	20.5	22	4.8	2.4	N	-	-	-	Chert (CCS)	FP
5LR235	345	CS	BF	40.7	32.3	6.9	7.7	N	-	-	-	Chert (CCS)	F
5LR235	346	CS	BF	21.3	6.1	2.3	0.4	N	-	-	-	Quartzite	FL
5LR235	347	CS	BF	23.6	14.6	3.4	1.1	Y	-	-	-	Chert (CCS)	FP

Site #	FS #	Artifact Class	Artifact Element	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Thermally Altered (Y/N)	PP: Neck Width (mm)	PP: Base Width (mm)	Typological Classification	Lithic Material Type	Portion
5LR235	350	CS	PP	11.6	7.7	2.2	0.2	N	-	-	Unassigned	Chert (CCS)	F
5LR235	348	CS	PP	9.5	10.3	2.8	0.2	Y	-	-	Unassigned Late Prehistoric	Chert (CCS)	FD
5LR235	349	CS	PP	8.9	13.8	3.7	0.4	Y	-	-	Unassigned Late Prehistoric	Chert (CCS)	FP
5LR236	45	CS	EMF	31.4	18.2	5.8	4.1	N	-	-	-	Chert (CCS)	C
5LR236	46	CS	EMF	30.3	42.7	9.6	10.4	N	-	-	-	Chert (CCS)	FD
5LR236	47	CS	EMF	98.5	49.8	14.1	74.4	N	-	-	-	Quartzite	C
5LR237	163	CS	BF	35.6	36.8	10.4	13.2	N	-	-	-	Chert (CCS)	FD
5LR237	164	CS	BF	29.9	35.5	6.7	11.4	Y	-	-	-	Chert (CCS)	FD
5LR237	165	CS	BF	22	22.1	7.3	3.7	Y	-	-	-	Chert (CCS)	FD
5LR237	167	CS	BF	23	37	6.5	7.4	N	-	-	-	Chert (CCS)	FM
5LR237	169	CS	BF	13	25	5.8	1.7	N	-	-	-	Chert (CCS)	FD
5LR237	170	CS	BF	12.8	16.1	3.7	1.2	N	-	-	-	Chert (CCS)	FM
5LR237	171	CS	BF	20.8	21.9	9.4	6.4	N	-	-	-	Chert (CCS)	FD
5LR237	166	CS	EMF	16.2	16.2	2.6	1.2	Y	-	-	-	Chert (CCS)	FD
5LR237	168	CS	SC	30.7	19.7	6.4	5.9	N	-	-	-	Chert (CCS)	FL
5LR237	178	CS	PP	18.4	10.3	4	1.1	N	n/a	n/a	Mount Albion	Chert (CCS)	FL
5LR237	179	CS	PP	37.5	21.4	6.8	6.2	N	12.7	13.8	Mount Albion	Quartzite	C
5LR237	180	CS	PP	46.3	17.1	7.2	6.3	N	11	13.1	Mount Albion	Quartzite	C
5LR237	181	CS	PP	25.9	17.2	5.2	2.4	N	11.6	12.3	Mount Albion	Quartzite	C
5LR237	174	CS	PP	17.2	14.2	2.8	1.1	N	n/a	n/a	unassigned	Quartzite	FM
5LR237	175	CS	PP	15.7	13.1	2.2	0.8	N	n/a	n/a	unassigned	Chert (CCS)	FM
5LR237	176	CS	PP	8.5	16.6	3.2	0.7	N	12*	16.6	Unassigned	Chert (CCS)	FP
5LR237	172	CS	PP	8.9	19.5	3.7	0.8	N	13.5*	19.5	Mount Albion	Chert (CCS)	FP
5LR237	173	CS	PP	15	8.9	4.6	0.8	N	n/a	n/a	Unassigned Archaic	Chert (CCS)	F
5LR237	177	CS	PP	17.3	12.2	4.3	0.9	N	n/a	n/a	Unassigned Archaic	Chert (CCS)	FL
5LR238	146	CS	BF	17.4	18.6	4.3	1.3	N	-	-	-	Chert (CCS)	FD
5LR238	143	CS	EMF	28	11.8	8.3	2.3	N	-	-	-	Chert (CCS)	C
5LR238	144	CS	EMF	15.4	19	6.7	3.2	Y	-	-	-	Quartzite	FL
5LR238	145	CS	EMF	20.7	19.5	2.9	1.7	N	-	-	-	Quartzite	FP

Site #	FS #	Artifact Class	Artifact Element	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Thermally Altered (Y/N)	PP: Neck Width (mm)	PP: Base Width (mm)	Typological Classification	Lithic Material Type	Portion
5LR238	147	CS	PP	18.5	13.5	3	0.7	N	n/a	13.1	Unnotched Triangular Point	Quartzite	C
5LR238	148	CS	PP	14.7	12.6	3.1	0.7	N	8	12.5	Plains Side-notched	Quartzite	C
5LR239	2	CS	PP	30.5	13	4.5	2.8	N	9.9	9.6	Possible Mountain-Foothills or Unassigned Paleoindian/Archaic	Chert (CCS)	FP
5LR239	1	CS	PP	17.2	13.4	3.7	1.3	N	n/a	n/a	Unassigned Archaic	Chalcedony (CCS)	F
5LR240	54	CS	BF	44.4	37	5.8	16.4	N	-	-	-	Chert (CCS)	C
5LR240	57	CS	BF	20.8	14.7	3.9	1	Y	-	-	-	Chert (CCS)	C
5LR240	55	CS	CORE	63.4	44.3	26.6	60.6	N	-	-	-	Chert (CCS)	C
5LR240	56	CS	EMF	23.5	8	2.8	0.7	N	-	-	-	Chert (CCS)	C
5LR240	66	GS	MET	39.3	39.8	18.5	58.1	N	-	-	-	Sandstone	F
5LR240	63	CS	PRE	16.1	17.7	3.1	0.9	N	-	-	-	Quartzite	FD
5LR240	65	CS	PP	6	8.5	2.8	0.1	N	-	-	Unassigned	Quartzite	FD
5LR240	58	CS	SC	30.1	26.1	4.8	4.4	N	-	-	-	Chert (CCS)	C
5LR240	61	CS	PP	26.5	22	5.2	3.8	Y	14.1	15.8	Mount Albion	Quartzite	FP
5LR240	62	CS	PP	19.8	21.6	4	1.8	Y	13.3*	n/a	Pelican Lake	Chert (CCS)	F
5LR240	59	CS	PP	44.5	19.8	5	4.5	N	12.1*	n/a	Unassigned Archaic	Quartzite	F
5LR240	64	CS	PP	17.1	12.7	4.8	1.3	N	n/a	n/a	Unassigned Archaic	Chert (CCS)	FL
5LR240	60	CS	PRE	44.9	24.1	6.2	8.1	Y	n/a	n/a	Unassigned Late Paleoindian	Chert (CCS)	C
5LR273	435	CS	BF	6.3	6.7	3	0.1	N	-	-	-	Chert (CCS)	FP
5LR273	436	CS	BF	28.4	8.8	4.6	1.1	N	-	-	-	Chert (CCS)	FL
5LR273	437	CS	BF	13.5	13.8	6	1	N	-	-	-	Chert (CCS)	FD
5LR273	441	CS	BF	22.8	15.7	5	2.1	Y	-	-	-	Chert (CCS)	F
5LR273	444	CS	BF	7.6	9	2.4	0.2	N	-	-	-	Chert (CCS)	FL
5LR273	445	CS	BF	10.8	8.9	4.8	0.7	N	-	-	-	Chert (CCS)	FD
5LR273	446	CS	BF	7.2	5.5	1.8	<0.1	N	-	-	-	Chert (CCS)	FL
5LR273	447	CS	BF	45.3	35.4	15.1	30.9	Y	-	-	-	Chert (CCS)	F

Site #	FS #	Artifact Class	Artifact Element	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Thermally Altered (Y/N)	PP: Neck Width (mm)	PP: Base Width (mm)	Typological Classification	Lithic Material Type	Portion
5LR273	449	CS	BF	20.7	17.9	5.4	2.4	Y	-	-	-	Chert (CCS)	FL
5LR273	451	CS	BF	32.6	17.1	7.7	5.3	N	-	-	-	Chert (CCS)	FM
5LR273	438	CS	EMF	49.3	31.6	7	13.6	N	-	-	-	Quartzite	F
5LR273	440	CS	EMF	27.8	16.4	2.3	1.4	N	-	-	-	Chert (CCS)	C
5LR273	448	CS	EMF	32	25.5	5.5	4.4	N	-	-	-	Quartzite	C
5LR273	450	CS	EMF	16.5	15	3.4	0.9	N	-	-	-	Chert (CCS)	F
5LR273	452	CS	EMF	12.2	16.8	5	0.9	Y	-	-	-	Chert (CCS)	F
5LR273	454	CS	GR	14.8	8.1	2.1	0.3	N	-	-	-	Chalcedony (CCS)	F
5LR273	439	CS	PRE	25.7	19.4	3.8	2.9	N	-	-	-	Chert (CCS)	FP
5LR273	453	CS	PRE	14.8	17.7	3.5	1	N	-	-	-	Chalcedony (CCS)	FP
5LR273	443	CS	PP	11.7	6.4	3	0.1	N	n/a	n/a	Hogback Corner-notched	Chert (CCS)	FL
5LR273	442	CS	PP	11.5	12.3	3	0.4	N	n/a	n/a	Unassigned	Chert (CCS)	FD
5LR274	31	CS	BF	20	14	4.3	1.9	N	-	-	-	Quartzite	FL
5LR274	32	CS	GR	11.3	9.6	2.5	0.6	N	-	-	-	Chert (CCS)	F
5LR274	30	CS	SC	39.8	32.2	13.1	14.6	N	-	-	-	Chert (CCS)	C
5LR274	33	CS	PP	12.6	7.7	2	0.2	N	n/a	n/a	Unassigned	Chalcedony (CCS)	FD
5LR1733	1	CS	PP	50.2	24.3	6	10.9	N	-	-	James Allen	Quartzite	FP
5LR1834	23	CS	BF	27.4	28.2	5	3.2	-	-	-	-	Chert (CCS)	FD
5LR14335	1	CS	PP	22	17.9	5.3	3.4	N	n/a	17.9	Unassigned Late Paleoindian	Quartzite	FP

TOOLS COLLECTED BY SITE IN 2019 (See also, Appendix C)

Key: FS#: Assigned sequentially by each individual site; **Artifact Class**: Chipped stone (CS); **Artifact Element**: Biface (BF), Scraper (SC), projectile point (PP), handstone (MAN), netherstone (MET), edge modified flake (EMF), core (CORE), drill (DR), preform (PRE), uniface (UN), graver (GR); **Portion**: Complete (C), near complete (NC), undetermined fragment (F), distal fragment (FD), proximal fragment (FP), medial fragment (FM), lateral fragment (FL); **Other**: Measurement based on incomplete artifact (*), not applicable (-), not available (n/a)

Site #	FS #	Artifact Class	Artifact Element	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Thermally Altered (Y/N)	PP: Neck Width (mm)	PP: Base Width (mm)	Typological Classification	Lithic Material Type	Portion
5LR237 / 5LR153	2019-97	CS	PP	13.6	18.5	3.2	1.1	N	10.7*	11.25*	Pelican Lake	Chert (CCS)	FM / FP
5LR237 / 5LR153	2019-101	CS	PRE	28.5	27.5	10.9	9.7	N	-	-	-	Quartzite	FP
5LR237 / 5LR153	2019-102	CS	PRE	40.9	27.8	11.5	15.7	N	-	-	-	Quartzite	FD
5LR237 / 5LR153	2019-99	CS	PP	37.5	18.5	5.7	5.1	N	15.1	17.1	Mount Albion	Quartzite	C
5LR237 / 5LR153	2019-100	CS	PP	20.3	22.9	6.6	3.8	N	16.2	18.6	Mount Albion	Quartzite	FP
5LR237 / 5LR153	2019-98	CS	PRE	21.2	11.7	5.5	1.5	N	-	-	-	Chert (CCS)	FM
5LR237 / 5LR153	2019-1	CS	BF	12.6	10.1	5.9	0.8	N	-	-	-	Chert (CCS)	F
5LR233	2019-2	CS	BF	50	42.2	9.9	29.9	N	-	-	-	Chert (CCS)	C
5LR233	2019-1	CS	BF	93.8	68.6	21.9	168	N	-	-	-	Chert (CCS)	C
5LR233	2019-4	CS	BF	46.1	20.7	9.2	9.2	N	-	-	-	Chert (CCS)	FL
5LR240	2019-25	CS	SC	28.4	21	8.5	4.7	N	-	-	-	Chert (CCS)	C
5LR240	2019-29	GS	MET	43.7	41	18.9	51.6	Y	-	-	-	Sandstone	F
5LR240	2019-28	CS	PRE	21.1	21.4	4.9	2.4	N	-	-	-	Quartzite	FP
5LR240	2019-30	CS	PP	18.7	18.6	5	1.3	N	n/a	n/a	Unassigned	Chert (CCS)	FD
5LR240	2019-26	CS	BF	15.6	20	3.6	1.3	N	-	-	-	Quartzite	FD
5LR240	2019-27	CS	PP	11.3	16.4	4.8	1	N	13.1	16.4	Mount Albion	Chalcedony (CCS)	FP
5LR174	2019-1	CS	Graver	16.4	22.3	2.4	1.1	N	-	-	-	Chert (CCS)	FL
5LR14336	2019-1	CS	PP	33.6	33.9	4.7	5.9	N	16.9	23.4	Pelican Lake/Elko	Chert (CCS)	FP
5LR14336	2019-2	CS	FK	16.7	15.9	3.9	1	N	-	-	-	Obsidian	C

APPENDIX C: MAPPED SURFACE ARTIFACTS BY SITE

UTM coordinates available in Buckner (2019)

Site #	FS #	Class	Element	Length (mm)	Cortex	Burning	Material	Collected
5LR174	5LR174-2019-1	CS	BF	16.4	N	N	CCS	Y
5LR174	5LR174-2019-2	CS	FK	17.78	N	N	CCS	N
5LR174	5LR174-2019-3	CS	FK	31.32	N	N	CCS	N
5LR174	5LR174-2019-4	CS	FK	9.56	N	N	CCS	N
5LR174	5LR174-2019-5	CS	FK	25.61	N	N	CCS	N
5LR174	5LR174-2019-6	CS	FK	20.87	N	N	CCS	N
5LR174	5LR174-2019-7	CS	FK	47.82	N	N	CCS	N
5LR229	5LR229-2019-1	CS	FK	19.92	Y	N	CCS	N
5LR229	5LR229-2019-2	CS	FK	18.26	N	N	Quartzite	N
5LR229	5LR229-2019-3	CS	FK	14.18	N	N	Quartzite	N
5LR229	5LR229-2019-4	CS	FK	24.43	N	N	CCS	N
5LR229	5LR229-2019-5	CS	FK	22.96	N	N	CCS	N
5LR233	5LR233-2019-1	CS	BF	93.8	N	N	CCS	Y
5LR233	5LR233-2019-2	CS	BF	50	N	N	CCS	Y
5LR233	5LR233-2019-3	CS	EMF	25.93	N	N	CCS	N
5LR233	5LR233-2019-4	CS	BF	46.1	N	N	CCS	Y
5LR233	5LR233-2019-5	CS	FK	42.44	N	N	CCS	N
5LR233	5LR233-2019-6	CS	FK	14.61	N	N	CCS	N
5LR233	5LR233-2019-7	CS	FK	8.95	N	N	CCS	N
5LR233	5LR233-2019-8	CS	FK	15.05	N	N	CCS	N
5LR233	5LR233-2019-9	CS	FK	23.14	N	N	Quartzite	N
5LR233	5LR233-2019-10	CS	FK	44.72	N	N	CCS	N
5LR233	5LR233-2019-11	CS	FK	16.7	N	N	CCS	N
5LR233	5LR233-2019-12	CS	FK	17.69	N	N	CCS	N
5LR233	5LR233-2019-13	CS	FK	24.94	N	N	CCS	N
5LR233	5LR233-2019-14	CS	FK	13.88	N	N	CCS	N
5LR233	5LR233-2019-15	CS	FK	12.01	N	N	CCS	N
5LR233	5LR233-2019-16	CS	FK	22.68	N	N	CCS	N
5LR233	5LR233-2019-17	CS	FK	8.33	N	N	CCS	N
5LR233	5LR233-2019-18	CS	FK	15.72	N	N	CCS	N
5LR233	5LR233-2019-19	CS	FK	13.44	N	N	CCS	N
5LR233	5LR233-2019-20	CS	FK	26.44	N	N	CCS	N
5LR233	5LR233-2019-21	CS	FK	21.94	N	N	Quartzite	N
5LR233	5LR233-2019-22	CS	FK	35.15	Y	N	CCS	N
5LR233	5LR233-2019-23	CS	FK	14.64	N	N	CCS	N
5LR233	5LR233-2019-24	CS	FK	18.18	N	N	CCS	N
5LR233	5LR233-2019-25	CS	FK	12.43	N	N	CCS	N
5LR233	5LR233-2019-26	CS	FK	16.67	N	N	CCS	N
5LR233	5LR233-2019-27	CS	FK	14.63	N	N	CCS	N
5LR233	5LR233-2019-28	CS	FK	15.98	N	N	CCS	N
5LR233	5LR233-2019-29	CS	FK	14.98	N	Y	CCS	N
5LR233	5LR233-2019-30	CS	FK	17.48	N	N	CCS	N

Site #	FS #	Class	Element	Length (mm)	Cortex	Burning	Material	Collected
5LR233	5LR233-2019-31	CS	FK	45.86	N	N	Quartzite	N
5LR233	5LR233-2019-32	CS	FK	17.33	N	N	CCS	N
5LR233	5LR233-2019-33	CS	FK	14.64	N	N	CCS	N
5LR233	5LR233-2019-34	CS	FK	26.89	N	N	CCS	N
5LR233	5LR233-2019-35	CS	FK	24.05	N	N	CCS	N
5LR233	5LR233-2019-36	CS	FK	23.81	N	N	CCS	N
5LR233	5LR233-2019-37	CS	FK	8.72	N	N	CCS	N
5LR233	5LR233-2019-38	CS	FK	12.93	N	N	CCS	N
5LR233	5LR233-2019-39	CS	FK	21.8	N	N	CCS	N
5LR233	5LR233-2019-40	CS	FK	16.28	N	N	CCS	N
5LR233	5LR233-2019-41	CS	FK	21.84	Y	N	CCS	N
5LR233	5LR233-2019-42	CS	FK	20.32	N	N	CCS	N
5LR233	5LR233-2019-43	CS	FK	20.6	N	N	CCS	N
5LR233	5LR233-2019-44	CS	FK	23.28	N	N	CCS	N
5LR233	5LR233-2019-45	CS	FK	17.97	N	N	CCS	N
5LR233	5LR233-2019-46	CS	FK	15.24	N	N	CCS	N
5LR233	5LR233-2019-47	CS	FK	23.89	N	N	CCS	N
5LR233	5LR233-2019-48	CS	FK	20.14	N	N	CCS	N
5LR233	5LR233-2019-49	CS	FK	28.44	N	N	CCS	N
5LR233	5LR233-2019-50	CS	FK	18.47	N	N	CCS	N
5LR233	5LR233-2019-51	CS	FK	15.02	N	N	CCS	N
5LR233	5LR233-2019-52	CS	FK	16.49	N	N	CCS	N
5LR233	5LR233-2019-53	CS	FK	29.86	N	N	CCS	N
5LR233	5LR233-2019-54	CS	FK	12.8	N	N	CCS	N
5LR233	5LR233-2019-55	CS	FK	15.84	N	N	CCS	N
5LR233	5LR233-2019-56	CS	FK	15.53	N	N	CCS	N
5LR233	5LR233-2019-57	CS	FK	20.34	N	N	CCS	N
5LR233	5LR233-2019-58	CS	FK	28.97	N	N	CCS	N
5LR233	5LR233-2019-59	CS	FK	21.47	N	N	CCS	N
5LR233	5LR233-2019-60	CS	FK	23.47	N	N	CCS	N
5LR233	5LR233-2019-61	CS	FK	31.53	N	N	Quartzite	N
5LR233	5LR233-2019-62	CS	FK	13.83	N	N	Quartzite	N
5LR233	5LR233-2019-63	CS	FK	17.71	N	N	Quartzite	N
5LR233	5LR233-2019-64	CS	FK	19.73	N	N	Quartzite	N
5LR233	5LR233-2019-65	CS	FK	6.89	N	N	Quartzite	N
5LR233	5LR233-2019-66	CS	FK	29.41	N	N	Quartzite	N
5LR233	5LR233-2019-67	CS	FK	18.33	N	N	CCS	N
5LR233	5LR233-2019-68	CS	FK	19.89	N	N	CCS	N
5LR233	5LR233-2019-69	CS	FK	9.86	N	N	CCS	N
5LR233	5LR233-2019-70	CS	FK	9.5	N	N	Quartzite	N
5LR233	5LR233-2019-71	CS	FK	13.59	N	N	CCS	N
5LR233	5LR233-2019-72	CS	FK	27.12	N	N	CCS	N
5LR233	5LR233-2019-73	CS	FK	14.98	N	N	CCS	N
5LR233	5LR233-2019-74	CS	FK	21.02	N	N	Quartzite	N
5LR233	5LR233-2019-75	CS	FK	28.83	N	N	CCS	N
5LR233	5LR233-2019-76	CS	FK	23.89	N	N	CCS	N
5LR233	5LR233-2019-77	CS	FK	30.73	N	N	CCS	N

Site #	FS #	Class	Element	Length (mm)	Cortex	Burning	Material	Collected
5LR233	5LR233-2019-78	CS	FK	25.9	N	N	CCS	N
5LR233	5LR233-2019-79	CS	FK	14.68	N	N	CCS	N
5LR233	5LR233-2019-80	CS	FK	12.81	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-1	CS	BF	12.6	N	N	CCS	Y
5LR153/5LR237	5LR237/5LR153-2019-2	CS	FK	7.1	N	N	Quartzite	N
5LR153/5LR237	5LR237/5LR153-2019-3	CS	FK	20.38	Y	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-4	CS	FK	42.31	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-5	CS	FK	18.28	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-6	CS	FK	17.82	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-7	CS	FK	13.49	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-8	CS	ANG	28.67	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-9	CS	FK	21.61	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-10	CS	FK	12.51	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-11	CS	FK	11	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-12	CS	ANG	13.41	N	Y	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-13	CS	FK	21.32	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-14	CS	FK	8.14	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-15	CS	FK	17.38	N	Y	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-16	CS	FK	10.37	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-17	CS	FK	14.79	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-18	CS	FK	10.85	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-19	CS	ANG	18.02	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-20	CS	FK	13.86	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-21	CS	FK	20.93	N	Y	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-22	CS	FK	21.84	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-23	CS	FK	11.91	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-24	CS	FK	11.65	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-25	CS	FK	7.84	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-26	CS	FK	9.5	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-27	CS	FK	35.6	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-28	CS	FK	14.12	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-29	CS	FK	19.33	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-30	CS	FK	12.13	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-31	CS	FK	7.91	N	N	CCS	N

Site #	FS #	Class	Element	Length (mm)	Cortex	Burning	Material	Collected
5LR153/5LR237	5LR237/5LR153-2019-32	CS	FK	21.38	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-33	CS	FK	15.13	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-34	CS	FK	16.4	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-35	CS	FK	12.06	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-36	CS	FK	11.32	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-37	CS	FK	9	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-38	CS	FK	4.92	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-39	CS	FK	17.11	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-40	CS	FK	5.78	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-41	CS	FK	14.61	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-42	CS	FK	13.77	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-43	CS	FK	9.42	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-44	CS	FK	8.56	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-45	CS	FK	32.43	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-46	CS	FK	13.54	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-47	CS	FK	23.88	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-48	CS	FK	11.42	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-49	CS	FK	19.4	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-50	CS	FK	15.45	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-51	CS	FK	17.36	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-52	CS	FK	9.75	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-53	CS	FK	10.55	Y	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-54	CS	FK	13.38	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-55	CS	FK	7.11	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-56	CS	FK	9.97	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-57	CS	FK	6.14	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-58	CS	FK	6.12	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-59	CS	FK	15.24	N	Y	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-60	CS	FK	13.99	Y	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-61	CS	FK	15.82	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-62	CS	FK	10.32	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-63	CS	FK	22.27	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-64	CS	FK	21.52	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-65	CS	FK	12.36	Y	N	CCS	N

Site #	FS #	Class	Element	Length (mm)	Cortex	Burning	Material	Collected
5LR153/5LR237	5LR237/5LR153-2019-66	CS	FK	20.28	N	Y	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-67	CS	FK	20.7	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-68	CS	FK	20.51	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-69	CS	FK	13.07	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-70	CS	FK	14.22	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-71	CS	FK	4.07	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-72	CS	FK	8.64	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-73	CS	FK	8.57	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-74	CS	FK	14.11	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-75	CS	FK	16.57	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-76	CS	FK	18.07	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-77	CS	FK	24.29	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-78	CS	FK	25.6	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-79	CS	FK	25.47	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-80	CS	FK	4.26	N	N	Quartzite	N
5LR153/5LR237	5LR237/5LR153-2019-81	CS	FK	16.71	Y	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-82	CS	FK	21.91	Y	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-83	CS	FK	12.5	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-84	CS	FK	16.61	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-85	CS	FK	13.62	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-86	CS	FK	12.68	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-87	CS	FK	16.75	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-88	CS	FK	11.75	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-89	CS	FK	12.06	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-90	CS	FK	18.6	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-91	CS	FK	12.9	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-92	CS	FK	21.57	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-93	CS	FK	14.18	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-94	CS	FK	23.19	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-95	CS	FK	16.89	N	Y	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-96	CS	FK	21.88	N	N	CCS	N
5LR153/5LR237	5LR237/5LR153-2019-97	CS	PP	13.6	N	N	CCS	Y
5LR153/5LR237	5LR237/5LR153-2019-98	CS	PRE	21.2	N	N	CCS	Y
5LR153/5LR237	5LR237/5LR153-2019-99	CS	PP	37.5	N	N	Quartzite	Y

Site #	FS #	Class	Element	Length (mm)	Cortex	Burning	Material	Collected
5LR153/5LR237	5LR237/5LR153-2019-100	CS	PP	20.3	N	N	Quartzite	Y
5LR153/5LR237	5LR237/5LR153-2019-101	CS	BF	28.5	N	N	Quartzite	Y
5LR153/5LR237	5LR237/5LR153-2019-102	CS	BF	40.9	N	N	Quartzite	Y
5LR153/5LR237	5LR237/5LR153-2019-103	CS	EMF	28.39	N	N	CCS	N
5LR240	5LR240-2019-1	CS	FK	16.91	N	N	CCS	N
5LR240	5LR240-2019-2	CS	FK	9.16	N	N	CCS	N
5LR240	5LR240-2019-3	CS	FK	16.57	N	N	Quartzite	N
5LR240	5LR240-2019-4	CS	FK	9.69	N	N	CCS	N
5LR240	5LR240-2019-5	CS	FK	11.15	Y	N	CCS	N
5LR240	5LR240-2019-6	CS	FK	11.54	Y	N	CCS	N
5LR240	5LR240-2019-7	CS	FK	10.7	N	N	CCS	N
5LR240	5LR240-2019-8	CS	FK	18.38	Y	N	CCS	N
5LR240	5LR240-2019-9	CS	FK	26.15	N	N	CCS	N
5LR240	5LR240-2019-10	CS	FK	15.68	Y	N	CCS	N
5LR240	5LR240-2019-11	CS	FK	14.89	N	N	CCS	N
5LR240	5LR240-2019-12	CS	FK	15.98	N	N	Quartzite	N
5LR240	5LR240-2019-13	CS	FK	19.16	N	Y	CCS	N
5LR240	5LR240-2019-14	CS	FK	20.23	N	Y	CCS	N
5LR240	5LR240-2019-15	CS	FK	15.08	Y	N	CCS	N
5LR240	5LR240-2019-16	CS	FK	8.52	N	N	CCS	N
5LR240	5LR240-2019-17	CS	FK	13.79	N	N	CCS	N
5LR240	5LR240-2019-18	CS	FK	20.01	Y	N	CCS	N
5LR240	5LR240-2019-19	CS	FK	17.18	N	N	CCS	N
5LR240	5LR240-2019-20	CS	FK	13.72	N	N	CCS	N
5LR240	5LR240-2019-21	CS	FK	30.04	Y	N	CCS	N
5LR240	5LR240-2019-22	CS	FK	10	N	N	CCS	N
5LR240	5LR240-2019-23	CS	FK	10.29	N	N	CCS	N
5LR240	5LR240-2019-24	CS	FK	14.08	Y	N	CCS	N
5LR240	5LR240-2019-25	CS	SC	28.4	N	N	CCS	Y
5LR240	5LR240-2019-26	CS	BF	15.6	N	N	Quartzite	Y
5LR240	5LR240-2019-27	CS	PP	11.3	N	N	CCS	Y
5LR240	5LR240-2019-28	CS	PRE	21.1	N	N	Quartzite	Y
5LR240	5LR240-2019-29	CS	MET	43.7	N	N	Sandstone	Y
5LR240	5LR240-2019-30	CS	PP	18.7	N	N	CCS	Y
5LR240	5LR240-2019-31	CS	FK	8.31	N	N	CCS	N
5LR240	5LR240-2019-32	CS	FK	10.54	N	N	CCS	N
5LR240	5LR240-2019-33	CS	FK	19.17	Y	N	CCS	N
5LR240	5LR240-2019-34	CS	FK	15.15	N	N	CCS	N
5LR240	5LR240-2019-35	CS	FK	21.6	N	N	CCS	N
5LR240	5LR240-2019-36	CS	FK	24.39	N	N	CCS	N
5LR240	5LR240-2019-37	CS	FK	19.48	N	N	CCS	N
5LR240	5LR240-2019-38	CS	FK	27.62	N	N	CCS	N
5LR240	5LR240-2019-39	CS	FK	19.43	Y	N	CCS	N
5LR240	5LR240-2019-40	CS	FK	40.1	N	N	Quartzite	N
5LR240	5LR240-2019-41	CS	FK	17.03	N	N	Quartzite	N

Site #	FS #	Class	Element	Length (mm)	Cortex	Burning	Material	Collected
5LR240	5LR240-2019-42	CS	FK	20.3	N	N	CCS	N
5LR240	5LR240-2019-43	CS	FK	17.27	N	N	CCS	N
5LR240	5LR240-2019-44	CS	FK	27.53	N	N	CCS	N
5LR240	5LR240-2019-45	CS	FK	36.21	Y	N	CCS	N
5LR240	5LR240-2019-46	CS	FK	19.15	Y	N	CCS	N
5LR240	5LR240-2019-47	CS	FK	16.33	N	N	CCS	N
5LR240	5LR240-2019-48	CS	FK	9.95	N	N	CCS	N
5LR240	5LR240-2019-49	CS	FK	13.42	N	N	CCS	N
5LR240	5LR240-2019-50	CS	FK	17.73	N	N	CCS	N
5LR240	5LR240-2019-51	CS	FK	27.31	N	N	CCS	N
5LR240	5LR240-2019-52	CS	FK	22.75	N	N	CCS	N
5LR240	5LR240-2019-53	CS	FK	30.92	N	N	CCS	N
5LR240	5LR240-2019-54	CS	FK	22.19	N	N	Quartzite	N
5LR240	5LR240-2019-55	CS	FK	20.62	N	N	CCS	N
5LR240	5LR240-2019-56	CS	FK	30.33	N	N	CCS	N
5LR240	5LR240-2019-57	CS	FK	7.25	N	N	CCS	N
5LR240	5LR240-2019-58	CS	FK	13.58	N	N	CCS	N
5LR240	5LR240-2019-59	CS	FK	16.12	Y	N	CCS	N
5LR240	5LR240-2019-60	CS	FK	16.3	N	N	CCS	N
5LR240	5LR240-2019-61	CS	FK	13.77	N	N	CCS	N
5LR240	5LR240-2019-62	CS	FK	15.03	N	N	CCS	N
5LR240	5LR240-2019-63	CS	FK	12.49	N	N	CCS	N
5LR240	5LR240-2019-64	CS	FK	22.41	Y	N	CCS	N
5LR240	5LR240-2019-65	CS	FK	16.88	Y	N	CCS	N
5LR240	5LR240-2019-66	CS	FK	23.8	Y	N	CCS	N
5LR240	5LR240-2019-67	CS	FK	17.4	N	N	CCS	N
5LR235/5LR273/5LR274	5LR235/273/274-2019-1	CS	FK	11.34	Y	N	CCS	N
5LR14336	5LR14336-2019-1	CS	PP	33.6	N	N	CCS	Y
5LR14336	5LR14336-2019-2	CS	FK	16.7	Y	N	Obsidian	Y

APPENDIX D: OBSIDIAN SOURCING OF RAWAH WILDERNESS MATERIALS

The following tables detail the results of an obsidian sourcing analysis undertaken for artifacts recovered from the Rawah Wilderness, including but not limited to the WBLR study area. These data are provided in this appendix courtesy of Jason LaBelle (See LaBelle 2009 for additional information).

Table A. Descriptive Attributes, Rawah Wilderness Obsidian Data (LaBelle 2009, LaBelle personal communication 2020). All samples were collected from Larimer County, Colorado.

Obsidian Sample Number	Smithsonian Site Number	Site Name	Catalog Number	Level	Age	Max Length (mm)	Max Width (mm)	Thickness (mm)	Mass (gm)	Cortex	Burning	Item	Portion	Comment
CSU 07-5	5LR164			Surface	Unknown	14.8	12.9	3.4	0.6	no	no	Edge modified flake	from a flake mid-section	
CSU 07-6	5LR164			Surface	Unknown	13.5	10.0	4.2	0.5	yes	no	angular debris	complete	
CSU 07-15	5LR174			Surface	Unknown	21.2	20.4	9.3	3.9	yes	no	core	complete	small pebble core, at least 6 removals, could have been done at same time, when smashed
CSU 07-16	5LR174			Surface	Unknown	24.1	12.1	4.8	1.3	no	no	flake	complete	very opaque, crystal structure

Obsidian Sample Number	Smithsonian Site Number	Site Name	Catalog Number	Level	Age	Max Length (mm)	Max Width (mm)	Thickness (mm)	Mass (gm)	Cortex	Burning	Item	Portion	Comment
CSU 07-17	5LR174			Surface	Unknown	9.3	13.4	1.8	0.2	no	no	flake	proximal	
CSU 07-7	5LR221	Montgomery Pass		Surface	Unknown	18.8	15.5	5.2	0.9	yes	no	flake	complete	cortex on platform; examine for edge use later
CSU 07-8	5LR221	Montgomery Pass	221 W	Surface	Unknown	10.1	10.3	4.6	0.4	yes	no	angular debris	complete	
CSU 07-9	5LR221	Montgomery Pass		Surface	Unknown	17.6	10.3	4.5	0.7	yes	no	flake	complete	
CSU 07-4	5LR225			Surface	Unknown	11.5	14.3	3.3	0.5	yes	no	flake	complete	Decortifac-tion flake off pebble
CSU 07-1	5LR244			Surface	Unknown	13.8	14.3	3.3	0.5	yes	no	flake	complete	cortex on platform only
CSU 07-2	5LR244			Surface	Unknown	10.1	10.1	3.3	0.2	yes	no	flake	midsection	

Table B. Trace Element Composition and Source Location, Rawah Wilderness Obsidian Data (LaBelle 2009, LaBelle personal communication 2020)

Obsidian Sample Number	Smithsonian Site Number	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba	Source	State
CSU 07-5	5LR164	995	233	8093	120	74	32	98	16		Malad, ID	ID
CSU 07-6	5LR164	1228	233	12172	177	39	64	258	31		Reas Pass, ID	ID
CSU 07-15	5LR174	869	815	7746	842	10	98	120	112		unknown, high Rb	UNK
CSU 07-16	5LR174	1166	346	11953	202	24	60	234	50		Fish/Partridge Cr, ID	ID
CSU 07-17	5LR174	1046	251	8230	127	79	20	91	11		Malad, ID	ID
CSU 07-7	5LR221	705	701	7193	815	11	87	120	123		unknown, high Rb	UNK
CSU 07-8	5LR221	777	733	7117	804	11	91	123	111		unknown, high Rb	UNK

Obsidian Sample Number	Smithsonian Site Number	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba	Source	State
CSU 07-9	5LR221	797	785	7661	825	10	91	116	116		unknown, high Rb	UNK
CSU 07-4	5LR225	1032	698	7375	782	13	94	107	112		unknown, high Rb	UNK
CSU 07-1	5LR244	739	661	6373	741	9	86	98	108		unknown, high Rb	UNK
CSU 07-2	5LR244	816	749	7308	839	14	91	118	119		unknown, high Rb	UNK